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# Measurements of atmospheric sea salt concentrations in Hawaii using a Tala kite

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ABSTRACT

An inexpensive and convenient method to sample sea salt concentrations in the lowest few hundred meters of the atmosphere was tested in Hawaii. The string to a Tala kite flying at about 150 m was intersected by thin steel wires on which sea salt collected during one hour long flights. Measurements were taken at two beaches and inland of one of them. Sampled concentrations compared well with same day aircraft and tower measurements. A surf zone upwind of one of the beaches produced surface concentrations as high as 250 $\mu g\ m^{-3}$, while the other beach without such a zone had less than 35 $\mu g\ m^{-3}$. The high concentrations at the surf beach extended above 145 m. Concentrations at 100 m correlated best to wind speed at this level and less so to previous two-day mean upwind surf condition, cloudiness and shower activity. Simultaneous measurements at and inland of the surf beach showed the effects of boundary layer mixing with a much more uniformly decreasing concentration profile as opposed to a steep decrease up to about 40 m at the beach.

## 1. Introduction

According to Blanchard et al. (1984), few studies of the vertical distribution of atmospheric sea salt concentrations have been done since early work by Woodcock (1953, 1962), Lodge (1955) and Durbin and White (1961). Of the studies since this time, a majority seems to have been carried out in Hawaii, e.g., Barger and Garrett (1970), Blanchard and Syzdek (1972), Woodcock (1972) and Blanchard et al. (1984).

In order to collect atmospheric sea salt, these studies exposed shallow trays, glass slides or thin wires to the air from towers or aircraft. As it is rather expensive and cumbersome to use aircraft or build towers, a new method to inexpensively and conveniently sample atmospheric salt was tested in Hawaii.

The method was an outgrowth of previous work where we used Tala* kites to measure mean wind speeds and turbulence at prospective wind turbine sites in Hawaii (Daniels and Oshiro, 1982a, b, c). We found the kites to be the by far most convenient way to measure winds at altitudes up to several hundred meters and have made extensive use of them. Salt concentrations were determined by intersecting the string to the kite with thin steel wires at ten equidistant levels from the ground to the kite flying at about 150 m as shown schematically in Fig. 1. The wind speeds at the wires, their angles to the vertical and their time of exposure determined the volume of air passing the wires. Salt concentrations were found by dividing the amount of salt collected on the wires with this air volume, and an assumed collection efficiency.

The main objectives of the research were: (1) to test the method of using kite suspended wires by comparing results with measurements made by Blanchard et al. (1984) during the same period; (2) to investigate the variation of salt with weather and surf conditions; (3) to investigate how the vertical salt profile changes as air from the ocean traverses land.

To achieve these objectives, 11 one-hour long runs were made in three areas on the Hawaiian island of Oahu (Fig. 2): Bellows Beach where

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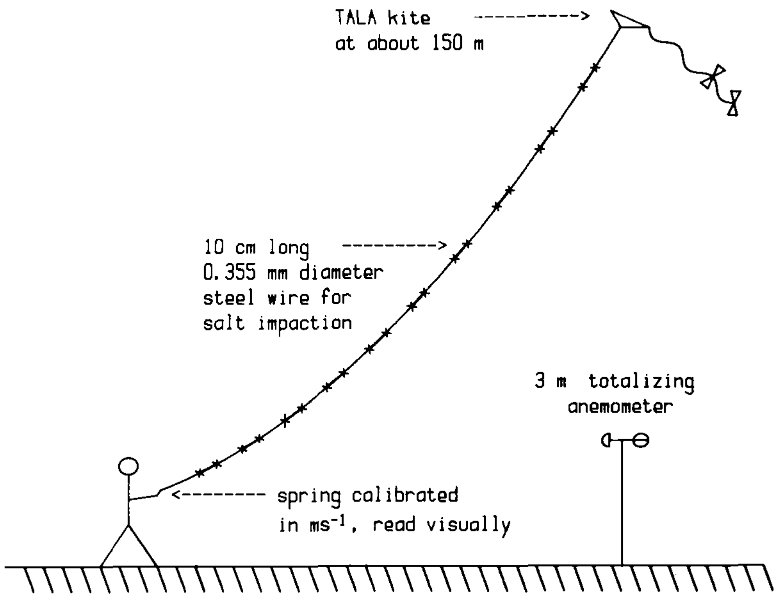


*Fig. 1.* Schematic drawing of atmospheric sea salt sampling using a Tala kite.

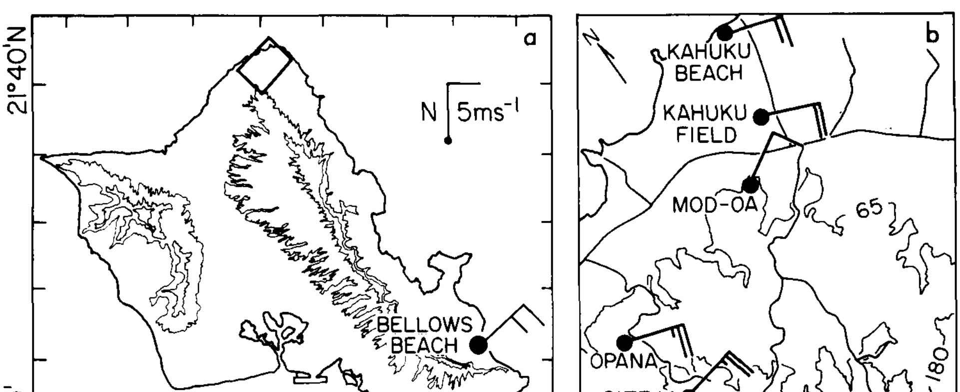


*Fig. 2.* Sites flown on Oahu, Hawaii November 1981 to March 1982. The map to the right is the enclosed area on the left map. Mean kite level (about 150 m) wind speeds and directions for the flights are indicated. Contours in m.

Blanchard et al. (1984) made measurements during the same period, Kahuku Beach further west with much stronger surf upwind and inland of this beach, Kahuku inland.

## 2. Determining sea salt concentrations

The Tala kite system consists of a small rectangular sled kite (35 × 45 cm) connected via a non-stretching Kevlar line to a spring. The force on the kite, as indicated by the length of the spring, was calibrated in a wind tunnel and read out as wind speed. The altitude of the kite and the wind direction can be calculated from the string length and azimuth and elevation of the kite. The system is accurate, inexpensive, portable, simple to operate and requires no external power. The read-out is generally visual but can be made electronically (Daniels and Oshiro, 1982c).

In order to sample salt concentrations in the air, the kite string was cut in ten places 12 m apart and 10 cm long steel wires with a diameter of 0.355 mm were inserted (Fig. 1). The wires were connected to the string by snap swivels at both ends for easy detaching. Before the tests, the wires were carefully cleaned and placed in glass bottles to prevent contamination. After the runs, the wires were disconnected from the string and put back into the bottles touching only the ends which were not included in the subsequent analysis.

In the laboratory, a 6-cm long mid section of each wire was rinsed off by a known amount of deionized and distilled water which was run through a flame atomic adsorption spectrometer. This analysis, which was identical to that used by Blanchard et al. (1984), gave the amount of sodium deposited on the wire. This value was then converted to sea salt by multiplying by 3.25, the ratio between sea salt and sodium in seawater. The amount of sea salt caught on wire sections ranged from 0.1 to 51 $\mu$g.

The sea salt concentration in the air was then calculated by dividing this value by the product of the collection efficiency and the air volume intersected by the wire. This volume is the product of the wind speed at the wire, the vertical projection of the wire, the time of exposure and the wire diameter. The wind speed at a wire was calculated by fitting a power law between the mean wind speed of a wind run anemometer operating at a height of 3 m underneath the kite, $U$ (3 m) (Fig. 1) and the mean kite wind speed, $U$ (kite):

$$U\,(\text{kite}) = U\,(3\text{ m})\,(\text{kite height}/3\text{ m})^{\alpha}. \tag{1}$$

With $\alpha$ known, the speed at any wire height is calculated by substituting the kite height with the height of the wire. The mean wind speed at the anemometer was the observed wind run divided by the period. The kite mean wind speed was the mean of one-minute observations. As an example, Table 1 shows calculated wind speeds at each wire for one day, 28 February 1982.

The vertical projections of the wires were calculated from two expressions describing the wind load on the kite string (Shien and Frost, 1980). For equilibrium and string motion only in one plane, the wind produces a force $\mathrm{d}T$ on a string element $\mathrm{d}s$ long at an angle $\theta$ from the vertical which results in a change of this angle $\mathrm{d}\theta$:

$$\begin{aligned} \mathrm{d}T &= [(\bar{\rho}g - b)\sin\theta - C_{\mathrm{b}}\rho R U^2 \cos\theta]\,\mathrm{d}s, \\ T\mathrm{d}\theta &= [(\bar{\rho}g - b)\cos\theta + C_{\mathrm{a}}\rho R U^2 \sin^2\theta \\ &\quad + C_{\mathrm{b}}\rho R U^2 \sin\theta]\,\mathrm{d}s, \end{aligned} \tag{2}$$

where $g$ is acceleration of gravity, $\rho$ the air density, $U$ the wind speed at the wire, $C_{\mathrm{a}}$ a

Table 1. *Parameter values for the 6-cm long wire section used in the chemical analysis for the kite flight on 28 February 1982 1450–1550 local time at Kahuku Beach*

| Level | Altitude m | Wind speed $\mathrm{m\,s^{-1}}$ | Wire angle deg | Wire vertical projection cm | Air volume $\mathrm{m^3}$ | Salt deposited $\mu$g | From levels below % | Salt concentration $\mu\mathrm{g\,m^{-3}}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 10.4 | 8.8 | 29.0 | 2.9 | 0.34 | 33.3 | 0.0 | 127.3 |
| 2 | 21.3 | 9.1 | 30.6 | 3.0 | 0.36 | 15.1 | 5.4 | 53.2 |
| 3 | 32.7 | 9.3 | 31.9 | 3.2 | 0.39 | 11.4 | 10.0 | 37.3 |
| 4 | 44.6 | 9.5 | 33.6 | 3.3 | 0.41 | 11.1 | 12.3 | 34.1 |
| 5 | 57.1 | 9.6 | 35.5 | 3.5 | 0.44 | 10.1 | 15.3 | 29.3 |
| 6 | 70.2 | 9.7 | 37.5 | 3.7 | 0.47 | 9.6 | 17.9 | 26.2 |
| 7 | 84.0 | 9.8 | 39.8 | 3.8 | 0.50 | 11.2 | 17.3 | 28.7 |
| 8 | 99.7 | 9.9 | 42.3 | 4.0 | 0.53 | 13.0 | 16.9 | 31.3 |
| 9 | 113.7 | 10.0 | 45.1 | 4.2 | 0.56 | 14.9 | 16.7 | 33.8 |
| 10 | 129.7 | 10.1 | 48.0 | 4.5 | 0.59 | 12.9 | 20.8 | 27.5 |

Collection efficiency 0.78–0.79. Kite angle 37.6°. String surface angle 27.7°. Speed power law coefficient ($\alpha$) 0.061. Time for one wire set up or take down 0.8 min.

coefficient related to the lift coefficient (= 1.1), $C_b$ a coefficient related to the lift and drag coefficients (= 0.02), $R$ the string radius, $\bar{\rho}$ the density per unit length of the wire, $b$ the buoyancy force per unit wire length ($= \pi\rho R^2 g$) and $T$ the total force on the section. The calculations began at the surface assuming initially that 96% of the measured force on the spring was caused by the kite and the remaining 4% by the string. The kite string angle at the surface was initially assumed to be 27°. Using 10 cm string sections the above expressions were calculated to yield increments for $T$ and $\theta$. This was done until the string length corresponded to the length used. At this point, calculated values for the angle to the kite from the observer and the combined force from the kite and the string were compared with measured ones. Initial values of $T$ and $\theta$ were then changed and the calculations repeated until there was an agreement between calculated and observed force and kite angle. Table 1 shows, for the sample run, the angle and vertical projection of each 6-cm wire section used for chemical analysis.

The exposure time for a run was one hour. It did however take from a half to two minutes to disconnect a wire, put it into the glass flask and wind in the string to the next wire. The combined time required for all 10 wires was noted and, by assuming that the procedure took equal time at each wire, the time per wire was calculated. The contributions to the salt catch on the wire from spending this length of time at all levels below its altitude during set up and take down were then subtracted to find the amount caught at the level of the wire. Obviously the calculations had to start with the lowest wire since a knowledge of concentrations at levels below were required. Table 1 includes the percentage of the catch that originated at levels below the wires during set up and take down. The table also gives the air volumes intersected by the 0.355 mm diameter wires at each level.

Collection efficiencies ($E$) were calculated from Langmuir's curves (1962) for cylinders as functions of droplet radius, air viscosity, droplet density, air density, wind speed and wire diameter. At, e.g., 10 $m s^{-1}$, $E$ varies from about 0.50 for 3 $\mu$m to 0.95 for 12 $\mu$m droplet radius for the wire size used. As $E$ does not vary linearly with droplet radius it was deemed preferable to

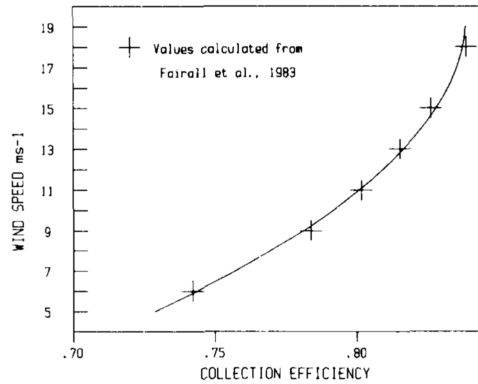


*Fig. 3.* Calculated collection efficiencies as a function of wind speed based on data from Fairall et al., 1983.

use a droplet size spectrum rather than an average droplet size for efficiency calculations. Since no size spectra were measured, it was necessary to use results from other projects. A number of salt particle spectra are available, e.g., McDonald et al. (1982) and Toba (1965). Recently, measurements were taken in a marine atmosphere by Fairall et al. (1983) who produce volume spectra for six wind speeds between 6 and 18 $m s^{-1}$. These spectra were combined with Langmuir's curves and the mean (volume) collection efficiency calculated for each wind speed are plotted in Fig. 3. A second-order curve was fit to give $E$ (%) as a function of wind speed, $U$ ($m s^{-1}$):

$$E = -5.23 \cdot 10^{-4} \cdot U^2 + 2.04 \cdot 10^{-2} \cdot U + 0.64. \quad (3)$$

For the eleven runs, $E$ varied from 0.71 to 0.81. This range is very close to that calculated by Blanchard et al. (1984) for similar sized wires exposed on a nearby tower.

## 3. Sources of errors

Errors are introduced both during measurements and subsequent analysis. As concentrations are inversely proportional to the wind speed, the potentially most serious source of error is probably interpolating the speed at the wires between surface anemometer and kite measurements. Unrepresentative surface winds or a non log-law profile could result in errors of up to an estimated 10%. By calibrating the kite spring before each run and subtracting the torque on the string (on the average 4%), kite winds are probably accurate to within a few percent (Baker et al., 1979) as is a calibrated wind run anemometer. Another potentially serious source of errors is variations in the time required to connect or remove a wire. During the first runs, up to 3 min were required to do this but as the operators became more efficient, this period was reduced to half a minute. If, e.g., the cleanest wire was exposed 50% longer at the lowest level than the average time used, the error would in the worst case be as much as 8%. Non-representative winds during set up and take down could also result in substantial errors. It is possible that some salt might have been lost when wheeling in the line, but this should be insignificant as the vibration of the string is about the same during this operation as during the flight.

Compared with other experiments (e.g., Blanchard et al., 1984), the wires were exposed to more air flowing by the wires which could result in so much salt being collected that some might coagulate and blow off. This would have resulted in a relatively uniform profile during runs with heavy salt concentration. As this is not evident in the data, saturation of the wires does not seem to be a problem. The relatively long time of exposure probably results in a build up of moisture on the wires which might have effected the collision efficiency but this was deemed only of secondary importance and ignored in the calculations.

In the analysis it was assumed that exposing the wires at an oblique angle to the wind had no effect on the collision process which seems reasonable. Errors introduced if the particle size distribution assumed was not representative for run should be at the most a few percent, since the range of $E$ was only 10%. Relative humidity was not routinely measured during the runs but the range was probably considerably less than 65 to 90% which produces a 5% error (Blanchard et al., 1984). The curves in Fig. 3 were normalized to 80% relative humidity which is probably close to the mean during the runs. Contamination of the wires can obviously produce large errors if care is not taken. Much smaller errors are probably inherent in the chemical analyses. In summary it seems reasonable that concentration estimates should be accurate to within 20%.

## 4. Results

To meet the three objectives listed in the introduction, measurements were made in three areas (Fig. 2). Mean wind speed and direction at kite altitude for all runs are shown in the figure

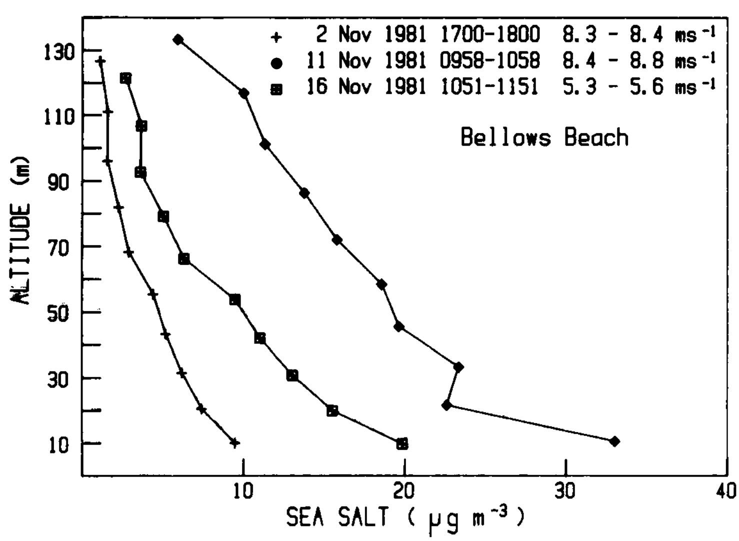


*Fig. 4.* Sea salt concentration profiles for the Bellows Beach flights.

for Bellows Beach and Kahuku Beach and for individual runs at the four Kahuku inland sites. The previous 2-day trajectory history for the air reaching the sites during the measurements was as follows. A well-developed front with strong winds, overcast and heavy showers had just passed the site when the first set of measurements were taken on 2 November. A high pressure ridge had been stationary to the north of the islands for several days prior to the second flight on 11 November, resulting in clear skies and low winds of variable direction. A front, less intense than the previous one, had just passed over the islands before the third flight on 16 November producing moderate NE winds, a narrow band of clouds and scattered showers. A weakening upper level trough east of the islands produced some clouds and a few passing showers with ENE winds decreasing from 10 to 5 $m s^{-1}$ prior to the fourth flight on 29 January. A front passed the island the day before the fifth flight on 28 February, but at the time of the flight, trades had returned with clear dry air. NE trades decreased from about 7 to 5 $m s^{-1}$ and skies were mainly clear as a result of a weakening ridge north of the islands before the sixth flight on 2 March. A cut-

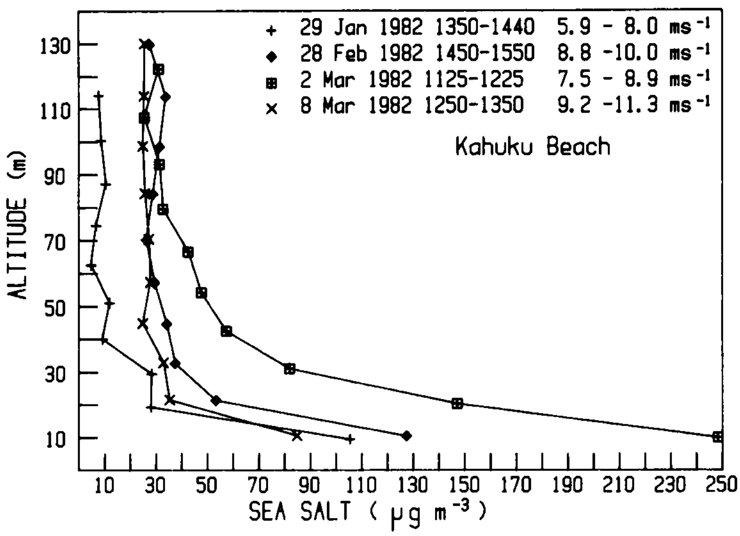


*Fig. 5.* Sea salt concentration profiles for the Kahuku Beach flights.

Table 2. *Surf height, estimated mean cloud cover, wind speed and shower activity for the previous two days, 10 m wind speed, 100 m wind speed and direction, 10 m and 100 m salt concentrations for the beach flights*

| Day | Surf height (m) | Prior 2-day upwind speed ($m s^{-1}$) | Prior 2-day upwind cloud cover (%) | Prior 2-day upwind shower activity | 10 m speed ($m s^{-1}$) | 100 m speed direction ($m s^{-1}$) | Salt concentration 10 m ($\mu g\ m^{-3}$) | Salt concentration 100 m ($\mu g\ m^{-3}$) |
|---|---|---|---|---|---|---|---|---|
| Bellows | | | | | | | | |
| 2 Nov 1981 | 3–4 | 9 | 100 | heavy | 4.3 | 8.5 NNE | 9 | 2 |
| 11 Nov 1981 | 2–3 | 2 | 10 | none | 8.5 | 8.8 NE | 34 | 12 |
| 16 Nov 1981 | 1–2 | 5 | 20 | scattered | 5.4 | 5.6 ENE | 19 | 4 |
| Kahuku | | | | | | | | |
| 29 Jan 1982 | 2–3 | 7 | 20 | scattered | 5.9 | 8.0 NNE | 97 | 9 |
| 28 Feb 1982 | 1–3 | 7 | 5 | none | 8.8 | 9.9 ENE | 129 | 33 |
| 2 Mar 1982 | 1–2 | 5 | 0 | none | 7.5 | 8.8 E | 236 | 29 |
| 8 Mar 1982 | 1–2 | 6 | 25 | scattered | 9.3 | 11.1 NE | 102 | 26 |

off low moved over the islands producing low clouds and showers prior to the last flight on 8 March. Concentration versus height for the 3 runs made at Bellows Beach are plotted in Fig. 4 and for the 4 runs at Kahuku Beach in Fig. 5. These figures also list the wind speed at the lowest and the highest wire. For these 7 beach flights, Table 2 lists upwind surf condition (from daily NOAA reports), mean upwind cloud cover (estimated from satellite pictures), open ocean wind speed and shower activity (estimated from surface charts) for the previous two days, 10 m wind speed, 100 m wind speed and direction, 10 m and 100 m salt concentrations. A second kite was flown inland during 3 of the 4 flights at Kahuku Beach. The vertical concentration profiles for these flights are shown in Figs. 6 to 8. During the last of the flights (Fig. 8), a third set

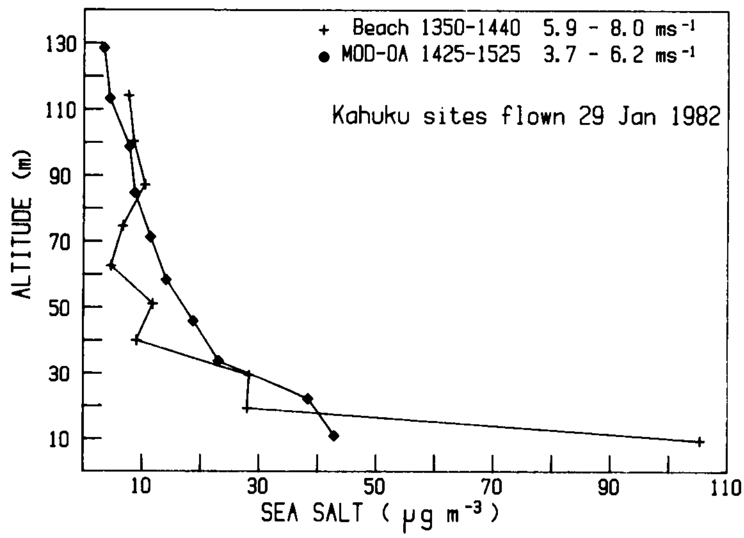


*Fig. 6.* Sea salt concentration profiles for the 29 January 1982 flights in Kahuku.

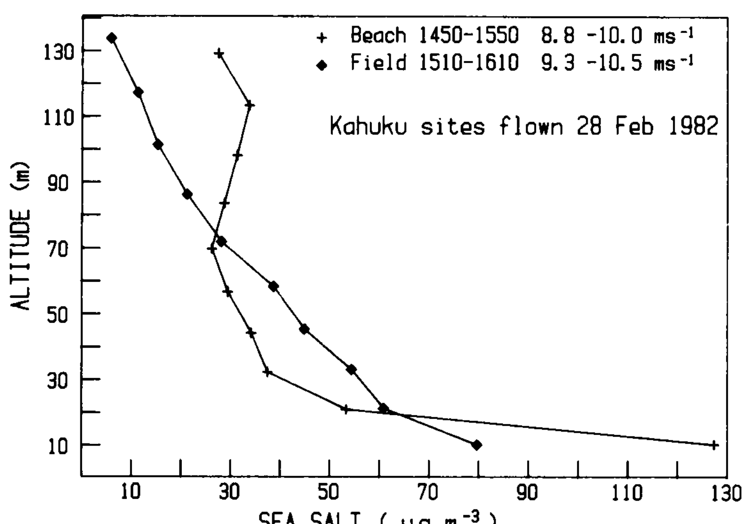


*Fig. 7.* Sea salt concentration profiles for the 28 February 1982 flights in Kahuku.

of measurements were taken immediately after the first two flights at a second inland location (site 14). Fig. 9 shows mean concentrations and wind speeds for the three areas flown: Bellows Beach, Kahuku Beach and Kahuku inland. The figure also includes measurements made by Blanchard et al. (1984) at Bellows Beach described in Section 5. This curve is the average of measurements made during eight days in October and November 1981. Standard deviation bars for the lowest and highest levels are included for each curve.

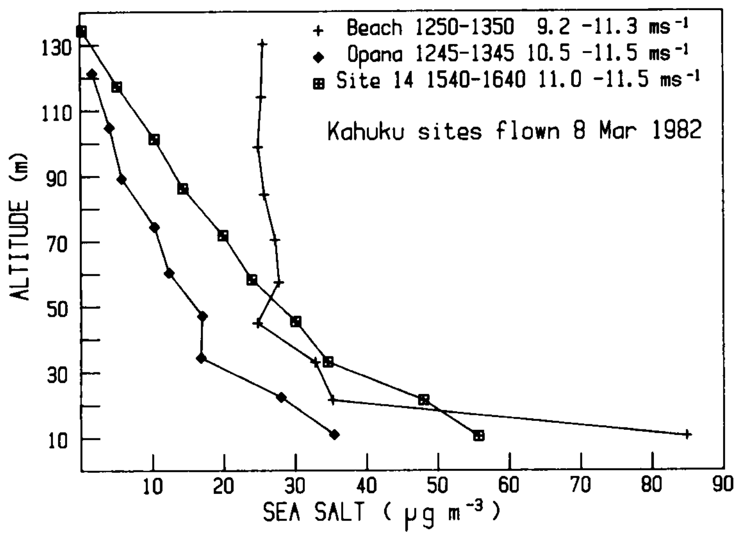


*Fig. 8.* Sea salt concentration profiles for the 8 March 1982 flights in Kahuku.

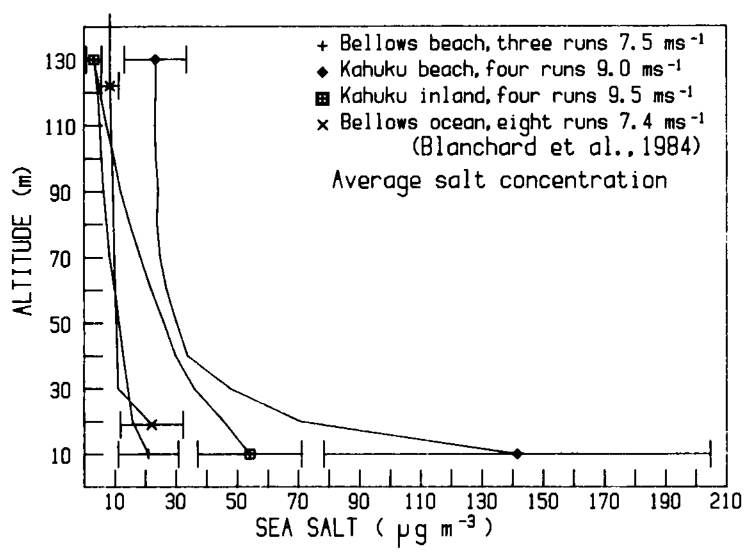


*Fig. 9.* Average sea salt concentration profiles for Bellows Beach, Bellows ocean, Kahuku Beach and Kahuku inland.

## 5. Discussion

The three objectives listed in the introduction are discussed separately below.

### 5.1. *Comparison with same day tower and aircraft measurements*

Blanchard et al. (1984) also sampled sea salt at Bellows Beach during October–November 1981. On 20 occasions, an aircraft flew upwind of the beach exposing small glass slides for 20 s at 12 elevations between 30 and 1000 m. On 8 of the occasions, 0.254 mm thick wires were exposed during two 10-min periods 20 min apart at 14 and 19 m on a tower at Bellows Beach very close to where the kites flew. Table 3 shows aircraft, tower and kite data collected on two days when both programs made measurements. On these occasions, the aircraft collected two 30 m samples, one 300 m upwind of the beach, the other about 20 km out at sea where the rest of the vertical profile was measured. Kite measurements are hourly averages. The agreement between the kite and Blanchard's measurements is good considering the short term variations in concentration that can occur as shown by the tower measurements. It was therefore concluded that the kite method was acceptable and the program continued.

### 5.2. *Sea salt variations in the boundary layer entering the islands as a function of weather and surf conditions*

The salt concentration in an air mass is the integrated result of various meteorological phenomena acting on it during the previous 1–4 days, the residence time of sea salt in the troposphere. Weather parameters measured at the site during the experiment, such as 10 m and 100 m wind speed, reflect short term local conditions and may therefore only be related to salt concentrations in a relatively minor way as compared with larger scale parameters such as daily averaged upwind cloud cover, wind speed, shower activity or surf conditions. In order to test the above hypothesis, these parameters were complied for the beach flights in Table 2. 100-m concentrations correlated best to 100 m wind speed (0.72), about equal to the previous two-day mean cloud cover, surf and shower activity (−0.65, −0.58, −0.62) and not at all to upwind trajectory mean wind speed (−0.19). 10-m concentrations show somewhat lower correlations to cloud cover, surf and shower activity but no correlation to any wind speed. The small number of experiments and two different locations limits however any generalization of the results.

Increasing salt concentrations with wind speed have been reported in the literature (Monahan, 1968; McDonald et al., 1982; Woodcock, 1953; Barger and Garrett, 1970). A quantitative expression has been suggested by Blanchard and Woodcock (1980):

$$C = 5(6.3 \times 10^{-6}\, H)^{(0.21 - 0.39 \log U)}, \quad (4)$$

where $C$ is the concentration in $\mu$g m$^{-3}$, $H$ the height in m and $U$ the wind speed in m s$^{-1}$. This expression estimated a mean 100 m concentration of 16.8 $\mu$g m$^{-1}$ while the measured mean was 15.8. The correlation at the 100 m altitude was 0.73. Estimated concentrations at 10 m using (4) did not correlate at all to measurements (0.10).

Table 3. *Same day aircraft, tower (Blanchard et al., 1984) and kite measurements of atmospheric salt concentrations*

| | Aircraft | | Tower | | Kite | | |
|---|---|---|---|---|---|---|---|
| | 30 m | 100 m | 14 m | 19 m | 15 m | 30 m | 100 m |
| 11 Nov 1981 | | | | | | | |
| salt concentration | 15–17 | 11 | 32 | 26–31 | 29 | 23 | 11 |
| local time | 1000–1030 | | 1430 | | | 0958–1058 | |
| 16 Nov 1981 | | | | | | | |
| salt concentration | 8 | 6 | 11–11 | 11–24 | 17 | 12 | 4 |
| local time | 1000–1030 | | 1430 | | | 1051–1151 | |

A result of a much more intense upwind surf zone, concentrations at the lowest levels at Kahuku Beach are five to ten times those at Bellows Beach. Though decreasing with height, this excess extends through all levels. At 100 m (4) over predicts Bellows concentrations while generally under estimating those at Kahuku. Thus higher wind speeds at Kahuku cannot explain the higher concentrations there.

On 2 November, the winds at Bellows were higher than on 16 November which should have resulted in higher concentrations. 2 November concentrations are however only half of those on 16 November which can most likely be attributed to the heavy showers scavenging the air earlier that day.

### *5.3. Sea salt profile modifications as the air enters land*

Figs. 6–8 show much higher surface concentrations at Kahuku Beach than further inland. The beach concentration profiles decrease rapidly in the first 40 m followed by slower decline up to about 90 m. Then a small increase occurs followed by constant concentration from about 110 m.

One possible explanation for this profile is that the salt in the lowest 100 m is dominated by large particles that have fallen to about 40 m between the surf zone and the kite measuring site on the beach. As the air travels further inland, boundary layer turbulence mixes the lowest 100 m into a uniformly decreasing profile which results in even slightly higher inland concentrations between 40 and 80 m than at the beach. In the two cases with high 130 m concentrations, Figs. 7, 8, upper level concentrations are reduced very much by the time the inland sites are reached indicating that the layer of high concentration caused by the surf did on those occasions not extend much above 130 m.

In Fig. 8 concentrations at Opana are less than at site 14 even though the wind trajectory over land is about the same: 6 km. It is possible that increased turbulence later in the day, when site 14 was flown, had mixed the surface salt excess more effectively to higher heights.

Average salt concentrations plotted in Fig. 9 show that while the mean for the two sets of measurements at Bellows Beach are close, the Kahuku Beach and Kahuku inland profiles are each distinctly different.

### *5.4. Corrosion of potential wind mills in the Kahuku area*

Blessed with strong and persistent trade winds, the Kahuku area has become one of the most important areas for wind-energy production in the world. So far some 15, 600 kW turbines operate in the area and the last in the NASA series of experimental turbines, the 3.5 MW Boeing MOD-5B has recently come on line there. The most successful of the NASA 200 kW MOD-0A turbine series also operated in Kahuku for a year and a half.

One potentially serious problem with the area is high corrosion rates as shown by the MOD-0A turbine whose blades had to be changed after a relatively short time because of extensive corrosion of the bolts holding the blade to the hub. Though designed for many years of operation, the turbine was dismantled after only 18 months, mainly due to severe corrosion. Calculations made by Boeing for the MOD-5B turbine estimate a mean concentration at a nacelle height of 60 m of 30 $\mu g\ m^{-3}$ which results in an ingestion of 3 kg of sea salt per year most of which has to be filtered out using glass fiber filters.

The two prime locations for wind turbines in Kahuku are on the beach and in the foothills some 5 km inland. The base of a turbine at the beach would experience much higher salt concentrations than the base of one further inland, but at nacelle heights around 50 m, the inland turbine would see more salt than the beach one because of the mixing within the boundary layer which grows as the air travels in over the land. Beside higher salt concentration levels, the boundary layer build up also results in higher turbulence levels inland.

## 6. Conclusion

During 11 one-hour long flights, the string to a Tala kite was intersected at 10 levels up to 130 m by thin wires on which salt particles collected. From the collected amount of salt, an assumed collection efficiency and a known amount of air passing by the wires, the average salt concentration in the air was calculated. This method proved versatile, accurate and inexpensive and probably the most convenient way to assess salt concentrations in the atmospheric boundary layer.

Salt concentrations at 100 m were reasonably well correlated to same level wind speeds, less so to upwind surf, shower activity and cloudiness, and not at all to estimated two day prior trajectory wind speed. An expression for salt as a function of wind speed and height developed by Blanchard and Woodcock (1980) fitted 100-m data rather well. Concentrations at 10 m did neither fit this expression nor were they correlated to any wind speed. Two beaches were sampled, one near a surf zone, the other far away. The surf zone beach had much higher concentrations at all levels with a mean 15 m height value of over 120 $\mu g\ m^{-3}$. The other beach had on the average about 20 $\mu g\ m^{-3}$ at this height, close to concentrations measured by Blanchard et al. (1984). On 3 occasions, sites inland of the surf beach were flown simultaneously. Inland profiles decreased much more uniformly with height reflecting effects of surface deposition and increased vertical mixing. This mixing will cause large inland wind turbines to experience some 10 to 20% higher nacelle height corrosion than beach turbines though the latter turbines will see much higher base concentration.

## 7. Acknowledgements

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