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RANGES AND EXTREMES OF THE NATURAL ENVIRONMENT

IN AND ABOUT THE HAWAIIAN ARCHIPELAGO

Related to Design Criteria

for

Ocean Thermal Energy Conversion Plants

by

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Abstract:

Examination of data from the water areas surrounding the Hawaiian Islands leads to the conclusion that Hawaii is suitably situated for ocean thermal energy conversion. Historical records of surface temperature for the Hawaiian area and the tropical and sub-tropical Pacific suggest that the proposed site may be vulnerable to significant epochal changes and yearly shifts in base temperatures but the site should still remain within the limits of operational parameters. Annual and monthly charts have been prepared for sea surface temperature, surface wind speeds and directions, and reported storm severities.

RANGES AND EXTREMES OF THE NATURAL ENVIRONMENT IN AND
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Introduction

In order to reduce the risk and ensure a reasonable long-term future for plants designed to make use of ocean thermal energy it is prudent to look beyond specific candidate sites and examine the potentialities of the area surrounding the site itself. In a fluid ocean, boundaries of one sort or another are not necessarily static and fixed within the medium. Qualities of the water at a specific geographical point may be subject to change due to variability of forces both spatial and temporal. Understanding of the range of conditions existing or observed in the past near or about a selected area may help designers provide for an efficient and safe machine economically justified by anticipated working situations bounded by the limits of potential variability.

For an expected life use of forty years or so a conversion plant for ocean thermal energy cannot rely with surety upon the conditions prevalent at a particular site today without taking into account the historical record of the area and the possibility of advective or temporal disruptions from normalcy in the future. It is for this reason that, in addition to site-specific information, data need to be gathered that reflect areal conditions and characteristics so that site data may be judged in context with the surrounding environment. Probably the most important environmental issues to affect the efficiency of an OTEC plant are the quantity and quality of the thermal resource and the exterior forces working upon the plant itself, namely, wind, sea, and currents. All of these are inter-related.

The major land areas of the Hawaiian Archipelago lie within the northern border of the Pacific tropical zone. However, the site situation of Hawaii should not be excluded from the possibilities of extra-tropical effects. In general, according to Bjerknes (1966), the large-scale atmospheric circulation cells connect the tropical regions to the higher latitudes. One of these cells is apparently driven by the east-west ocean temperature gradient where colder air from the eastern end of the Tropical Pacific is warmed, soaking up moisture during its westward flow, eventually rising to return aloft. Another cell carries heat, momentum, and energy to higher latitudes subsiding in the mid-latitude high-pressure system for return at the surface. The combination of these two major air-sea couplings results in the trade-wind system. With Hawaii lying near the border between heat-absorbing and heat-extractive oceanic regions the effects of climatic variability may have an important bearing upon the environmental condition.

Storm anomalies superimposed over the general trade-wind system are phenomena related to the major circulation cells and are part of the air-sea exchange processes. Figures 1 and 2 from Crutcher and Quayle (1974) give the annual tropical storm and hurricane stages for the Eastern North Pacific Ocean. In almost every 5° unit of latitude and longitude the movements of the storm centers show westward components as the dominant direction with northward components showing secondary dominance. As storm severity progresses to hurricane stage the northward movement takes over as the dominant direction resulting in heat and energy transference to higher latitudes. Surface trade winds, on the other hand, have strong southerly components combined with their westward driving force.

The principal criterion for maintaining efficient, uninterrupted operation of an OTEC plant aside from the deployment and mechanics needed to remain on station is the state of the thermal resource. This efficiency will de-

pend, for the most part, on the constancy of the temperature differences as well as the scalar differences between the warm water used for evaporation of the working medium and the cold water needed for condensation. The constancy of cold water for plant use presents no particular problem provided the intake is deep enough to be clear of thermocline effects. International Geophysical Year observations (Fuglister, 1960) make it clear that temporal constancy of deep water is characteristically stable. IGY observations compared with those taken thirty years earlier showed very little change in deep water properties.

Surface warm water, on the other hand, is seasonally changeable, and, in most instances, variable from one year to the next or from one epoch to another. These temporal differences in temperature should be examined from various viewpoints in order to make reasonable estimates of operating ranges consistent with available data and foreseeable trends. This report gives the results of analysis of documented marine observations of sea surface temperatures and surface wind speeds and directions. The areas covered are the six Marsden Square units surrounding the Hawaiian Archipelago.

Sea Surface Temperature Distribution

Before beginning a surface temperature discussion it is instructive to examine the cold water resource by displaying a north-south profile showing the deep temperature distribution for the North Pacific Ocean. Figure 3, from Barbee (1965), shows a PIONEER profile extending from Pacific high latitudes to the Hawaiian Islands. This profile shows the geographical continuity, for example, of the 7° C. isotherm at 500 meters depth off Hawaii with surface waters near the Aleutian Islands. The colder temperatures, as cold as 4° C., show the same continuity. However, the greatest volumes of isothermally cold water as represented by the vertical gradient off Hawaii appear to be about the 4.5° C. isotherm at depths centered around 800 meters. This level is possibly the best target depth for cold water intake

thereby assuring ample quantity and sufficient temperature difference with surface values.

In this report use is made of available sea surface temperature observations and attendant weather data from the file of Surface Marine Observations (SMO) maintained by the National Weather Service. These observations are filed within the appropriate Marsden Square in which they were taken. Finer delineation into one-degree units of latitude and longitude would be ideal if the numbers of observations were evenly distributed and sufficient in number in all the degree-squares for un-biased significance. The procedure used by Bunker (1976) for heat-flux determinations was followed by breaking down the 10° by 10° Marsden Square areas into smaller parcels of varying sizes and proportions in order to minimize bias from observational distributions and heterogeneities of temperature. The general trend of properties was roughly delineated as a first-order demarcation of the smaller units. Within these first-order boundaries a Marsden Square was parceled into still smaller units by qualifying the numbers of observations contained within a unit to no less than 200. This procedure tended to homogenize each unit while retaining statistical significance as much as possible. Figure 4 is a chart of the Hawaii area showing the unit divisions for each Marsden Square (MSQs051-053, and MSQs087-089).

As Wolff (1977) reports, one-degree samplings in the Hawaiian area accumulated over 30 years is too sparse and insufficient to apply standard statistics. This judgment is based on the total availability of standard oceanographic observations obtained from hydrographic stations, bathythermographs, and in-situ devices. Robinson (1976) has used a network of one-degree squares to compile a computer-generated atlas of surface temperatures for the entire North Pacific. This atlas does not rely on statistical evaluation. Instead, its contouring consistency is based on two-dimensional interpolations. Final contours did not deviate from numerical values by more than 0.1° C. Robinson also

gives a thorough review of available temperature data extending as far back in time to 1804 with reported data from Russian ships in the North Pacific.

Surface Marine Observations compiled by the National Weather Service give an order of magnitude greater coverage in numbers of observations and areal distribution than the standard hydrographic methods for obtaining temperature. The increased numbers of observations from SMO permit historical evaluation as well as depiction of average conditions, as shown in Figure 5 from Miller (1978). This figure, representing the surface temperature record for MSQ 088, shows a startling temperature rise in the decade of the 1930's thereby raising a question about the objectivity of average temperature interpretations. For instance, a thirty-year record compiled from the recent past could easily have missed this spectacular temperature rise as well as the preceding long cold period shown in the figure.

Miller (1978) ascribes the 1930-1940 temperature rise off Hawaii as possible compensation by way of heat advection northward in response to massive cold water intrusions southward off the coast of Japan. On the other hand, Barnett (1978) relates anomalous temperature epochs in the tropical Pacific, including Hawaii, to events occurring off South America, namely the occurrences of El Niño. The El Niño phenomenon consists of an abnormal increase in water temperature off the South American coast and is associated with large-scale perturbations in the ocean-atmosphere system. Corollary anomalies at the sea surface extend as far west as the International Date Line in the tropical Pacific, as illustrated in Figure 6 from Barnett (1978). Bjerknes (1966) suggests that weaknesses or even elimination of easterly winds in the Eastern and Central Tropical Pacific bring about a temporary halt to equatorial upwelling (El Niño) initiating a chain of events producing abnormally high surface temperatures in the tropical Pacific. Subsequent air-sea interactions produce far-reaching effects affecting global climate.

The results of compiling and contouring sea surface temperatures from the Marine Deck (SMO) are shown in Figures 7 through 19 giving the annual and monthly temperature distributions for the years 1941-1972. One hundred twenty thousand observations have been used to compile these distributions with the majority located in the northern half of the Hawaiian area (20° N.- 30° N.). The contouring of the surface isotherms agrees with the contouring in the Robinson atlas with temperature gradients following lines more or less normal to north-northeast / south-southwest directions. However, absolute values of temperature differ from the Robinson atlas by as much as 1° C. These differences lie within the computed standard of deviation, roughly 1° to 1.5° C.

In general, the temperature transitional months of August, September, and October show warping of contours in the lee of the main Hawaiian Islands. This warping is symptomatic of the eddy structures which appear to be common here (See Wyrski, et al, 1967). In the area of Keahole Point on the island of Hawaii (Unit 1 of MSQ 052) temperatures range from 24.7° C. in April to 27.1° C. in September. The very comprehensive study reported by Bathen (1975) shows a wider range of temperature off Keahole Point. The larger range is probably due to the local wind distributions and recurrent eddies.

Sea Surface Wind Distribution

The influence of trade wind stress is graphically shown in the Robinson atlas along the 10° N. latitude where the depths of the thermocline are depicted in monthly "mean depths to the top of the thermocline". These depths progressively increase from about 50 feet off Central America to as much as 400 feet off New Guinea. Also, in response to wind stress, sea level rises 0.7 dynamic meters between South America and New Guinea (Bjerknes, 1966). The flow pattern of the North Equatorial Current maintained by the steady trade winds must change if the balance of forces is interrupted by a shift in the wind flow.

The annual and monthly means of wind speed and direction about the Hawaiian Archipelago are shown in Figures 20 through 32. The annual average winds appear to be extremely consistent from one unit area to the next adjoining unit. In the southern portion of the Hawaiian waters wind speeds vary from 7 to 8 meters per second consistently coming from the 065° to 075° sector. In the north the wind is more easterly varying from 090° to 075° with the same speed as in the southern area. Closer examination of the figures reveals that the winds from the east, upon approaching the Hawaiian Island chain, diverge about 10° and, after passing over the islands, converge again in the same amount. The steering effect of the islands upon surface wind direction is apparent in each monthly chart although winter variability in the north tends to obscure conclusive identification.

Surface circulation in the lee of the islands is probably influenced by the varying conditions of the surface winds brought about by the frictional effects of the islands interacting with trade wind direction and intensity. Various cruises in the period, 1965-1967, taken in the leeward waters between Oahu and Hawaii and reported by Wyrski, et al (1967) discovered complex thermal structures associated with local wind distributions. Eddies of the order of 100 kilometers in diameter with geostrophic velocities in excess of 100 centimeters per second have been observed. Local winds emphasize the frictional effects of the land masses upon wind direction. Bathen (1975) shows that wind distributions at Kailua Airport on Hawaii favor the 050° direction both winter and summer, a direction which is about 25° off the general sea surface pattern.

Maximum Observed Winds

Hawaii appears to be relatively free of severe storm winds compared with some other areas within the same latitudinal belt. This statement does not preclude the possibility of hurricane-intensity storms.

It is based on the reported observations within the Surface Marine Observations storage program. In comparison with the Caribbean-Gulf of Mexico area, as reported by Miller (1977) the maximum observed winds, on the average, appear to have been 30 meters per second less in the Hawaiian area, a significant difference. Except for a few cases maximal winds were reported at approximately 25 meters per second or about 50 knots. This disparity between Hawaii and the Caribbean may have been due to the numbers and frequencies of observations. There has been a twenty-fold increase in numbers of Caribbean-Gulf observations over those in Hawaii reported in spite of the areas studied being of comparable size. Increased density of shipping increases the chances of reporting greater prevalence of storm severity.

Figure 33 through 45 show the areas and maximum intensity of storms reported. Figure 33 gives a summation for the entire period of record noting the months of occurrence. The winter months of December, January, and February seem to be periods of maximum intensity, generally, but the severest storms reported have occurred in summer and fall. Figures 1 and 2, referred to earlier, demonstrate that tropical and hurricane storms are not unknown to the Hawaiian area. Probabilities for at least one storm in a given year have been estimated at 43% for tropical storms and 14% for hurricanes. The so-called Kona winds off Hawaii are from the south and are consistent with the projected movements of storms in the area.

Summary

The stability of the Hawaiian area for siting of ocean thermal energy conversion plants seems assured from historical temperature records and other environmental considerations in and around the Hawaiian Islands. As a

target site for this purpose the lee side of the island of Hawaii presents a favorable location. It is suggested that designers plan for cold water intakes at depths of 800 meters where temperatures centering around 4.5° C. should be available in almost unlimited quantity. Average surface temperature for design should be 25.9° C. with a seasonal variation of plus or minus 1.2° C. and a mixed depth of approximately 75 to as much as 100 meters. Platform moorings should be prepared ordinarily for currents in excess of 100 cm./sec. or 2 knots and winds in excess of 25 m./sec. or 50 knots possibly with maximum intensity from the south or southeasterly direction. Normal winds ranging from 6 to 7 m./sec. can be expected from the east-northeast direction. For long-term operation the base surface temperatures may vary as much as a degree or so dependent upon climatic events in the tropical Pacific but there is sufficient thermal reserve to maintain continued operations.

References

- Barbee, W. D., 1965.
 Deep circulation, Central North Pacific Ocean: 1961, 1962, 1963.
 U.S. Coast and Geodetic Survey, Research Paper, 104 pp.
- Barnett, T. P., 1978.
 The role of the oceans in the global climate system.
 In: Climatic Change, J. Gribbin, Editor; Cambridge University Press, Cambridge: pp. 157-177.
- Bathen, K. H., 1975.
 An evaluation of oceanographic and socio-economic aspects of a nearshore ocean thermal energy conversion pilot plant in subtropical Hawaiian waters.
 Final Report, NSF Grant AER 74-17621-A01:
 5 sections and appendix.

Bjerknes, J., 1966.

A possible response of the atmospheric Hadley circulation to equatorial anomalies of ocean temperature.
Tellus, 4: pp. 820-829.

Bunker, A. F., & L. V. Worthington, 1976.

Energy exchange charts of the North Atlantic Ocean.
Bull. Amer. Meteor. Soc., V. 57, N. 6: pp. 670-678.

Crutcher, H. L., & R. G. Quayle, 1974.

Mariners worldwide climatic guide to tropical storms at sea.

Naval Weather Service Command, NAVAIR 50-1C-61.

Fuglister, F. C., 1960.

Atlantic Ocean Atlas of temperature and salinity profiles and data from the International Geophysical Year of 1957-1958.

Woods Hole Oceanographic Institution Atlas Series, Volume 1.

Miller, A. R., 1977.

Ranges and extremes of the natural environment related to design criteria for ocean thermal energy conversion plants.

Unpublished Manuscript, Woods Hole Oceanographic Institution Technical Report: WHOI-77-61.

Miller, A. R., 1978

A preliminary comparative study of historical sea surface temperatures at potential OTEC sites.

Proceedings, Fifth Annual Conference on OTEC, Miami, Florida.

Robinson, M. K., 1976.

Atlas of North Pacific monthly mean temperatures and mean salinities of the surface layer.

Naval Oceanographic Office Reference Publication 2.

Wolff, P., et al, 1977.

OTEC thermal resource report for Hawaii.

Ocean Data Systems, Inc., Monterey, California.

Wyrcki, K., J. B. Bucks, R. C. Latham, & W. Patzert, 1967.
Oceanographic observations during 1965-1967 in the
Hawaiian Archipelago.
Hawaiian Institute of Geophysics, University of
Hawaii; HIG-67-15.

Figure Legend

1. Tropical Storm Stage - Eastern North Pacific (from Crutcher & Quayle, 1974).
2. Hurricane Stage - Eastern North Pacific (from Crutcher & Quayle, 1974).
3. Temperature Section-161° W. Longitude-1962 (from Barbee, 1965).
4. Chart of the Hawaiian area in MSQ units and subdivisions.
5. Annual Sea Surface Temperatures for MSQ 088-Hawaii, 1922-1972 (from Miller, 1978).
6. Sea Surface Anomalies (°C.) during warm (July, 1972) and cold (July, 1973) epochs (from Barnett, 1978).
7. Average Surface Temperature, Hawaiian Pacific, Annual.
8. Average Surface Temperature, Hawaiian Pacific, January.

19. Average Surface Temperature, Hawaiian Pacific, December.
20. Average Wind Speed & Direction, Hawaiian Pacific, Annual.
21. Average Wind Speed & Direction, Hawaiian Pacific, January.

32. Average Wind Speed & Direction, Hawaiian Pacific, December.
33. Maximum Winds observed & reported, Hawaiian Pacific, 1941-72.
34. Maximum Winds observed & reported, Hawaiian Pacific, Jan.

45. Maximum Winds observed & reported, Hawaiian Pacific, Dec.

Abstract

Examination of data from the water areas surrounding the Hawaiian Islands leads to the conclusion that Hawaii is suitably situated for ocean thermal energy conversion. Historical records of surface temperature for the Hawaiian area and the tropical and sub-tropical Pacific suggest that the proposed site may be vulnerable to significant epochal changes and yearly shifts in base temperatures but the site should still remain within the limits of operational parameters. Annual and monthly charts have been prepared for sea surface temperature, surface wind speeds and directions, and reported storm severities.

Figure 1.

Hurricane Stage - Eastern North Pacific

ANNUAL

Figure 2.

(14)

Temperature (°C) Section 3, September 1962.

Figure 3.

Figure 4.

Figure 5.

Sea surface anomalies ($^{\circ}\text{C}$) during warm (El Niño) and cold epochs in the equatorial Pacific. (a) July 1972, (b) July 1973. Data from the National Marine Fisheries Service, Fishing Information.³⁸

Figure 6.

AVERAGE SEA SURFACE TEMPERATURE
 HAWAII
 FROM 119,542 SURFACE MARINE OBSERVATIONS
 1941 - 1972

Figure 7.

Figure 8.

FEBRUARY

0.8 = STANDARD DEVIATION

Figure 9.

(21)

Figure 10.

Figure 11.

Figure 12.

JUNE

AVERAGE SEA SURFACE TEMPERATURE

0.8 = STANDARD DEVIATION

Figure 13.

0.8 = STANDARD DEVIATION

Figure 14.

Figure 16.

OCTOBER

AVERAGE SEA SURFACE TEMPERATURE

0.8 = STANDARD DEVIATION

Figure 17.

NOVEMBER

0.8 = STANDARD DEVIATION

Figure 18.

0.8 = STANDARD DEVIATION

Figure 19.

FROM 119,542 SURFACE MARINE OBSERVATIONS
1941-1972

Figure 20.

Figure 21.

Figure 22.

Figure 23.

Figure 24.

Figure 25.

Figure 26.

Figure 27.

Figure 28.

Figure 29.

Figure 30.

Figure 31.

Figure 32.

Figure 33.

Figure 34.

Figure 35.

Figure 36.

Figure 37.

Figure 38.

JUNE

Figure 39.

JULY

Figure 40.

Figure 41.

SEPTEMBER

Figure 42.

OCTOBER

Figure 43.

Figure 44.

Figure 45.

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