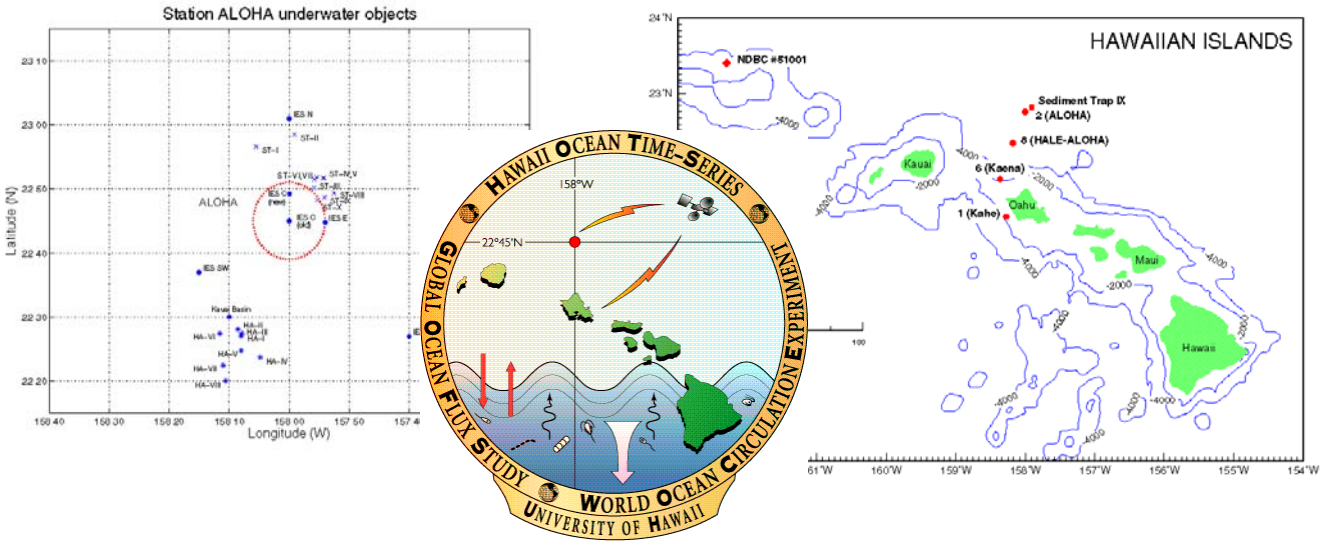

Hawaii Ocean Time-series Station

The deep ocean station ALOHA (*A Long-term Oligotrophic Habitat Assessment*), is located at 22°45'N, 158°W approximately 100 km north Oahu, Hawaii (4740 m of water), and representative of the North Pacific Subtropical Gyre biome. The objectives of HOT project, which operates since October 1988, are: (*1*) to document seasonal and interannual variability in water mass structure, (*2*) to relate water mass variations to gyre fluctuations, (*3*) to develop a climatology of biogeochemical rates and processes including microbial community structure, primary and export production and nutrient inventories and (*4*) to estimate the annual air-to-sea flux of carbon dioxide.

HOT Historical Background

One of the deep-ocean weather stations established in the fifties to improve global weather prediction capabilities, Station November, was occupied (1966 - 1974) in the eastern sector of the North Pacific Ocean gyre at 30ºN, 140ºW. During the 1970s, most of the U.S. weather ship stations were phased out of operation and were eventually replaced with more cost-effective, unattended ocean buoys, which measured standard meteorological parameters as well as basic wave characteristics but few, if any, hydrographic variables. A deep ocean hydrostation (Station GOLLUM, 1969 - 1970) was established by the University of Hawaii at a location 47 km north of Oahu, beyond the biogeochemical influences of the Hawaiian Ridge. On approximately monthly intervals, 13 two-day research cruises were conducted to observe and interpret variations in particulate organic matter distribution and other parameters in the water column. Although repeated ocean observations were not made during the Geochemical Ocean Sections Study (GEOSECS) Pacific Ocean expedition (1973 - 1974), high-precision data, including numerous radioactive and stable isotopic tracers, were collected in the central North Pacific Ocean (in particular, GEOSECS stations 202, 204, 212 and 235) to be used as the basis for assessing "change". In the early 1970's the North Pacific experiment (NORPAX) focused on large-scale ocean-atmosphere interactions (e.g., El Niño), and long-range climate forecasting. Furthermore, the extensive 15-cruise Hawaii-to-Tahiti Shuttle time-series experiment (1979 - 1980) was conducted to obtain direct measurements of the temporal variations in thermal structure of the equatorial Pacific region, and provided a rich dataset including measurements of DIC and primary productivity. In 1981, the IOC/WCRP Committee on Climate Change in the Ocean (CCCO) recognized this deficiency, and endorsed the initiation of new ocean observation programs. A station was occupied (October 1986 - May 1988) in the northeast Pacific Ocean as one component of the Vertical Transport and Exchange (VERTEX) research program, with the objective to investigate seasonality in carbon export from the euphotic zone in relation to contemporaneous primary production. Despite the comprehensive scope and intensity of this research project, the sampling frequency was clearly inadequate to

resolve much of the natural variability in this oligotrophic oceanic ecosystem. In response to the growing awareness of the ocean's role in climate and global environmental change, and the need for additional and more comprehensive oceanic time-series measurements, after a workshop on "Global Observations and Understanding of the General Circulation of the Oceans" in 1983, the U.S. component of the World Ocean Circulation Experiment (WOCE) was developed to understand the general circulation of the global ocean, to model its present state and its evolution in relation to long-term changes in the atmosphere, and to provide the scientific background for designing an observation system for long-term measurement of the large-scale oceanic circulation. In a parallel effort, in 1986, the International Council of Scientific Unions (ICSU) established the International Geosphere-Biosphere Programme (IGBP), and the following year, the Joint Global Ocean Flux Study (initially set up by the Scientific Council of Oceanic Research after the creation of the US GOFS) was designed as a Core Project of IGBP, to focus on the oceanic carbon cycle, its sensitivity to change and the atmosphere-ocean CO_2 balance regulation. In July 1988, two separate proposals submitted to the US-WOCE and US-JGOFS committees to establish a multi-disciplinary, deep water hydrostation in Hawaiian waters were funded and Station ALOHA was officially operational.

HOT Program Design and Implementation

The primary objective of HOT is to obtain a long time-series of physical and biochemical observations in the North Pacific subtropical gyre, addressing the goals of the U.S. Global Change Research Program. The objectives specific to the ***WOCE*** program are to document and understand seasonal and interannual variability of water masses, to relate water mass variations to gyre fluctuations, and to develop a climatology of short-term physical variability. The objectives specific to the ***JGOFS*** program are to document and understand seasonal and interannual variability in the rates of primary production, new production and particle export from the surface ocean, to determine the mechanisms and rates of nutrient input and recycling, especially for N and P in the upper 200-m of the water column, and to measure the time-varying concentrations of DIC in the upper water column and estimate the annual air-to-sea CO_2 flux. In addition to these general primary objectives, the physical oceanographic component of HOT provides CTD/rosette sampling support for the JGOFS time-series sampling program, and supports development of new instrumentation for hydrographic observations. To date, HOT has supported research and provided logistical support for lowered acoustic profiler measurements of currents in support of WOCE objectives, for dissolved oxygen sensor technology and for numerous complementary biogeochemical research programs.

The Station ALOHA was selected in deep water (>4000 m), upwind (north-northeast) of the main Hawaiian Islands and free from coastal ocean dynamics and biogeochemical influences, and close enough to the port of Honolulu to make relatively short duration (<5 d) monthly cruises logistically and financially feasible. A desirable, but less stringent criterion was to locate the station at, or near, previously studied regions of the central North Pacific Ocean. After consideration of these criteria, the primary sampling site was established at 22º45'N, 158º00'W at a location approximately 100 km north of Oahu, and generally restrict our monthly sampling activities to a circle with a 6 nmi radius around this nominal site. Station ALOHA is in deep water (4750 m) and is more than one Rossby radius (50 km) away from steep topography associated with the Hawaiian Ridge.

Field sampling strategy

The HOT program was initially conceived as being a deep-ocean, ship- and mooring-based observation experiment that would have an approximately 20-year lifetime. Consequently, a core suite of environmental variables was selected, that is expected to display detectable change on time scales of several days to one decade. Since 1988, the interdisciplinary station work has included physical, chemical, biological and sedimentological observations and rate measurements. Except for

the availability of existing satellite and ocean buoy sea surface data, the initial phase of the HOT program (Oct. 1988 – Feb. 1991) was entirely supported by research vessels. In February 1991, an array of inverted echo sounders (IES) was deployed around Station ALOHA and in June 1992, a sequencing sediment trap mooring was deployed a few km north of it. In 1993, the IES network was replaced with two strategically positioned instruments: one at Station ALOHA and the other at the coastal station Kaena. A meteorological-physical-biogeochemical mooring was deployed from January 1997 to June 2000 for high frequency atmospheric and oceanic observations.

HOT cruises are conducted at approximately monthly intervals primarily by the scientists at the University of Hawaii. To date, the field observations have not been severely aliased by month, season or year, except perhaps for a slight under representation of data collected during June and November and slight over representation in October. Sampling at Station ALOHA typically begins with sediment trap deployment followed by a deep CTD cast and a "burst series" of 12-18 consecutive casts, on 3-hr intervals, to 1000 m to span the local inertial period (~31 hr) and three semidiurnal tidal cycles, and to calculate an average density profile from which variability on tidal and near-inertial time-scales has been removed. These average density profiles are useful for the comparison of dynamic height and of the depth distribution of chemical parameters at monthly intervals. This sampling strategy is designed to assess variability on time scales of a few hours to a few years. High frequency variability (<6 hr) and variability on time scales of between 3-60 d. are not adequately sampled at the present time. However, no field sampling program, including the HOT program, regardless of its intensity, can adequately resolve the entire spectrum of variability that theoretically exists in the ocean.

Core measurements, experiments and protocols

Ideally, the suite of core measurement parameters should provide a data base to validate existing biogeochemical models and to develop improved ones. The list of core measurements has evolved since the HOT program inception in 1988, and now includes both continuous and discrete physical, biological and chemical ship-based measurements, *in situ* biological rate experiments, and observations and sample collections from bottom-moored instruments and buoys. Continuity in the measurement parameters and their quality, rather than continuity in the methods employed, is of greatest interest. Detailed analytical methods are expected to change over time through technical improvements.

All HOT core measurement data are publicly available (http://hahana.soest.hawaii.edu) approximately one year after collection, along with annual data reports, published and distributed through the US JGOFS-Planning Office.

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For further information, see the HOT website at: **hahana.soest.hawaii.edu/hot/hot_jgofs.html**.