EXHIBIT "C"

MARINE WATER QUALITY MONITORING

MAKENA RESORT, MAKENA, MAUI

WATER CHEMISTRY

REPORT I-2005

Prepared for

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I. PURPOSE

Makena Resort Corp. has constructed two 18-hole golf courses (North and South Courses) within the boundaries of the Makena Resort Development. The study area off the Makena site fronts approximately 5.4 miles of coastline. The area is bounded by Papanui Stream (Nahuna Point) on the north and Pu`u Olai (Ahihi Bay) on the south. No part of the project involves direct alteration of the shoreline or nearshore marine environments.

Evaluations of other golf courses and other forms of resort development located near the ocean in the Hawaiian Islands reveal that while there is detectable input to the coastal ocean of materials used for fertilization of turfgrass and landscaping, there are few, if any, effects that can be considered detrimental to the marine ecosystem (Dollar and Atkinson 1992). Thus, there is no *a priori* reason to suspect that the construction and responsible operation of the golf courses at Makena will cause any harmful changes to the marine environment. Nevertheless, in the interest of assuring maintenance of environmental quality, and as a means of ensuring that proper procedures are set forth, a condition of the Land Use Commission District Boundary Amendment for the project was the implementation of an ongoing marine monitoring program off the Makena Resort Development. The primary goals of the program are twofold: 1) to assess the degree that materials used on the Resort property to enhance turf growth and landscaping leach to groundwater and subsequently reach the ocean, and 2) to determine the fate of these materials within the nearshore zone. In terms of determining fate, the question that is addressed is if the materials that originate from Resort activities disperse with little or no effect, or do they cause changes in water quality sufficient to alter marine biological community structure?

The rationale of the monitoring program is to conduct repetitive evaluations of water chemistry at the same locations at regular time intervals (twice per year). This strategy allows for determination of variations in effects from the Resort in both space (at different locations along the shoreline) and time. These studies also fulfill condition No. 10, Declaration of Conditions pertaining to the Amendment of the District Boundary, as required by the Land Use Commission, dated April 17, 1998. The following report presents the results of the fifteenth increment in the monitoring program, and contains data from water chemistry sampling conducted on June 19, 2005.

II. ANALYTICAL METHODS

Three survey sites directly downslope from the Makena Golf Course site have been selected as sampling locations. A fourth site, located offshore of an area with minimal land-based development, particularly golf course operations, was selected as a control. Figure 1 is a map showing the shoreline and topographical features of the Makena area, and the location of the North and South Golf Courses. The four survey sites are depicted as transects perpendicular to the shoreline extending from the shoreline out to what is considered open coastal ocean (i.e., beyond the effects of activities on land). Survey Site 1 is located near the northern boundary of the project site off Nahuna Point; Survey Site 2 bisects Makena Bay near Makena Landing, which is directly downslope of the Makena. Site 3 bisects the middle of the South course on the north side of Maluaka Point. Site 4, which is considered the Control site, is located at the northern boundary of the 'Ahihi-Kina`u natural area reserve offshore of the 1790 lava flow and approximately 1-2 miles south of the existing Makena Golf courses (Figure 1). In 2003, Site 3 was relocated from a location at the southern boundary of the project offshore of Oneloa Beach to the location directly off the golf course described above. Site 3 was relocated because the original location consistently showed virtually no input of groundwater to the ocean, hence offered little potential for evaluating effects from the project. The new location of Site 3 is directly downslope from both the portion of the golf course nearest to the ocean, as well as newly constructed residences. As a result, the new location represents an area that reflects the maximum influence of several land uses on nearshore water quality. Several private residences are also located near the shoreline in the vicinity of Control Site 4, while land use upslope of this survey site consists primarily of cattle grazing.

All fieldwork was conducted on June 19, 2005 using a small boat. Environmental conditions during sample collection consisted of calm seas, mild winds (10-15 knots) and sunny skies. Water samples were collected at stations along transects that extend from the highest wash of waves to approximately 125-200 meters (m) offshore at each site. Such a sampling scheme was designed to span the greatest range of salinity with respect to freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of shoreline modification. With the exception of the two stations closest to the shoreline (0 and 2 m offshore), samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the sea surface, and a bottom sample was collected within one m of the sea floor.

Water samples beyond 10 meters (m) from the shoreline were collected using a 1.8-liter Niskin-type oceanographic sampling bottle. This bottle was lowered to the desired depth in an open position where spring-loaded endcaps were triggered to close by a messenger released from the surface. Upon recovery, each sample was transferred into a 1-liter polyethylene bottle until further processing. For nearshore samples within 10 m of the shoreline, water samples were collected in 1-liter polyethylene bottles by divers swimming from the shoreline.

Water samples were also collected from seven golf course irrigation wells (No's 1, 2, 3, 4, 5, 6, and 10) and two irrigation lakes on June 29, 2005.

Subsamples for nutrient analyses from all water sources were immediately placed in 125-milliliter (ml) acid- washed triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the Water Quality Standards, Department of Health, State of Hawaii. These criteria include: total nitrogen (TN) which is defined as dissolved inorganic nitrogen plus dissolved organic nitrogen, nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+), total phosphorus (TP) which is defined as dissolved inorganic phosphorus plus dissolved organic phosphorus, chlorophyll a (Chl *a*), turbidity, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{3-}) and silica (Si) were reported because these constituents are sensitive indicators of biological activity and the degree of groundwater mixing, respectively.

Analyses for NH_4^+, PO_4^{3-}, and NO_3^- + NO_2^- (hereafter termed NO_3^-) were performed using a Technicon autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (TON) and dissolved organic phosphorus (TOP) were calculated as the difference between TN and inorganic N, and TP and inorganic P, respectively. Limits of detection for the dissolved nutrients are 0.01 µM (0.14 µg/L) for NO_3^- and NH_4^+, 0.01 µM (0.31 µg/L) for PO_4^{3-}, 0.1 µM (1.4 µg/L) for TN and 0.1 µM (3.1 µg/L) for TP.

Chl *a* was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5°C for 12-24 hours, and the fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer (level of detection 0.01 µg/L). Salinity was determined using an AGE Model 2100 laboratory salinometer with a precision of 0.0003‰.

In situ field measurements included water temperature, pH, dissolved oxygen and salinity which were acquired using an RBR Model XR-420 CTD calibrated to factory specifications. The CTD was a readability of 0.001°C, 0.001pH units, 0.001% oxygen saturation, and 0.001 parts per thousand (‰) salinity.

Nutrient, turbidity, Chl *a* and salinity analyses were conducted by Marine Analytical Specialists located in Honolulu, Hawaii. This laboratory possess the appropriate acceptability ratings from the State of Hawaii Dept. of Health, and the U.S. EPA

III. RESULTS

A. Horizontal Stratification

Table 1 shows results of all marine water chemical analyses for samples collected off Makena on June 19, 2005 reported in micromolar units (µM). Table 2 shows similar results presented in units of micrograms per liter (µg/L). Tables 3 and 4 show geometric means of ocean samples collected at the same sampling stations during the fifteen surveys to date from August 1995 to June 2005. Table 5 shows water chemistry measurements (in units of µM and µg/L) for samples collected from irrigation wells located on the Makena Resort Golf Courses. Concentrations of twelve chemical constituents in surface and deep-water samples from the June 2005 sampling are plotted as functions of distance from the shoreline in Figures 2 and 3. Mean concentrations (±standard error) of twelve chemical constituents in surface and deep water samples from the entire sampling program at Makena Resort, as well as data from the most recent sampling, are plotted as functions of distance from the shoreline in Figures 4-15.

On all four sampling transects concentrations of dissolved Si, NO_3^-, and TN were elevated by one to two orders of magnitude across the sampling regime. Values of salinity show the mirror image with low values within the nearshore zone (Figures 2-3, 4-9, Tables 1 and 2). The horizontal gradients were steepest on Transects 1 and 4, where the peak value of NO_3^- (44.08 and 17.5 µM, respectively) at the shoreline was more than two orders of magnitude higher than the concentration 150 m from shore (~0.1µM). Salinity at the shoreline of both Transects 1 and 4 was about 5‰ lower than the offshore values (Table 1). On Transects 2 and 3, horizontal gradients of Si, NO_3^- and salinity were also evident, but of a generally smaller magnitude than on Transects 1 and 4 (Tables 1 and 2).

Phosphate phosphorus (PO_4^{3-}) exhibited relatively small horizontal gradients with highest values generally nearest to the shoreline (Figure 2, Tables 1 and 2). The horizontal gradients of PO_4^{3-}, however, were small compared to Si and NO_3^-.

The pattern of elevated Si, NO_3^- and TN with a corresponding reduced salinity is indicative of groundwater entering the ocean near the shoreline. Low salinity groundwater, which contains high concentrations of Si, NO_3^-, TN and PO_4^{3-} (see values for well waters in Table 5), often percolates to the ocean near the shoreline, resulting in a distinct zone of mixing in the nearshore region. In the Kihei-Makena area, the zone of mixing generally extends to about 100 m of the shoreline, although in June 2005, elevated concentrations of Si, NO_3^- and TN were evident along the entire length of Transect 1(Tables 1 and 2).

Dissolved nutrient constituents that are not associated with groundwater input (NH_4^+, TP, TON, TOP) did not show any distinct patterns with respect to distance from the shoreline (Figure 2). Concentrations of TON, TP and TOP were essentially constant along the entire length of each transect (Figure 2). Concentrations of NH_4^+ were high near the shoreline and in a zone between 50 m and 150 m of the shoreline at Site 4 (Figure 2). Surface concentrations of turbidity and Chl *a* were highest near the shoreline and decreased with increasing distance offshore at all four sites (Table 1, Figure 3).

Among the four transect sites; values for turbidity were highest on Transect 2, which is the typical pattern seen on previous survey dates (Table 1, Figure 3). Transect 2 bisects Makena Bay, which is semi-enclosed embayment with a silt/sand bottom rather than the predominantly "hard" reef bottoms that occur at the three other transect sites. In addition, it has been observed that during flash floods originating in the ranch lands upslope of the Makena Resort terrigenous sediment flows to the ocean in Makena Bay. As a result of wave-induced resuspension of the naturally occurring silt/sand substratum, as well as terrigenous runoff which may be partially retained within the embayment, turbidity has been typically elevated at Transect 2 relative to the other transect sites. It is important to note that in surveys conducted since July 2002, water clarity in Makena Bay has improved greatly compared to preceding surveys in 2001 which reflected conditions following substantial input of terrigenous materials from a flash-flood that occurred in October 1999.

Surface water temperature measured beyond 10 m of the shoreline ranged between 25.7°C and 25.8°C during the June 2005 survey (Tables 1 and 2). Owing to the length of time between collection and return to the shoreline, temperature was not measured in the samples collected by divers.

B. Vertical Stratification

In many areas of the Hawaiian Islands, input of low salinity groundwater to the nearshore ocean creates a distinct buoyant surface lens that can persist for some distance offshore. Buoyant surface layers are generally found in areas where turbulent processes (primarily wave action) are insufficient to completely mix the water column in the nearshore zone. Figures 2 -15 and Tables 1 and 2 show concentrations of water chemistry constituents with respect to vertical stratification. During the June 2005 survey, vertical stratification was evident for Si, NO_3^-, TN and salinity over the entire length of the transects at Sites 1, 2 and 3. At Site 4, breaking surf of 1-2 m near the shoreline resulted in a relatively unstratified water column during the June 2005 survey.

With respect to the other constituents measured, there were variations between surface and deep samples, however, the differences were generally small and no apparent trend with distance offshore was evident (Figures 2-15). One exception was the distinctly higher concentration of Chl *a* in the surface waters compared to the deeper water at Site 1 (Figures 3 and 4).

C. Temporal Comparison of Monitoring Results

Figures 4-15 show mean concentrations (±standard error) of water chemistry constituents from surface and deep samples at all four sites during the fifteen monitoring surveys conducted from 1995 to 2005. In addition, the results of the most recent survey also shown.

Examination of the plots in Figures 4-15 show results of the most recent survey in comparison with the overall trend from the entire monitoring program. The only constituent that shows a consistent excursion above the mean values on all four transects is temperature. The water temperature of ~25.8°C at all stations in June 2005 was substantially higher than the mean values for the fifteen surveys to date.

Other instances where present survey results vary from the mean values are evident. At Sites 1, 3 and 4, Chl *a* concentrations from the present survey were above the mean value measured at all points along the transects (Figures 6, 12 and 15). The elevated concentrations of Chl *a* cannot be considered a response to input from the Makena Resort, as Site 2, which is closest to the golf course did not exhibit an elevated trend. In addition, Site 4, which is considered the Control beyond the influence of the golf course showed distinctly elevated concentrations in the June 2005 survey relative to the mean values. Measurements of NH_4^+ during June 2005 at Site 4 also exceeded the mean value at three of the seven sampling stations (Figure 13).

The dissolved nutrient in nearshore waters that is most liable to originate from leaching of golf course fertilizers is NO_3^-. During the June 2005 survey, concentrations of NO_3^- and TN in the nearshore area of Site 3 were well above the mean value (Figures 10 and 11). Site 3 is directly downslope of the portion of the golf course nearest to the ocean. It is also the site of active housing construction during the past six months. Continued monitoring will indicate whether or not operation of the golf course has resulted in incremental additions of nutrients to the composition of groundwater in this area. At the other transect sites, NO_3^- levels measured during this survey were of the same magnitude as the 10-year mean values.

D. Conservative Mixing Analysis

A useful treatment of water chemistry data for interpreting the extent of material input from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question (Officer 1979, Dollar and Atkinson 1992, Smith and Atkinson 1993).

Figure 16 shows plots of concentrations of four chemical constituents (Si, NO_3^-, PO_4^{3-}, NH_4^+) as functions of salinity for samples collected in June 2005. Figures 17 and 18 show the same type of plot with data grouped by transect site for the composite of all past surveys, as well as for the most recent survey. Each graph also shows two conservative mixing lines that are constructed by connecting the end member concentrations of open ocean water with two sources of groundwater: 1) irrigation well No. 4 located on the North Course of the Makena Resort and 2) the irrigation lake that was fed by irrigation wells 2, 3 and 4. If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or very near, the conservative mixing line. If, however, external material is added to the system through processes such as leaching of fertilizer nutrients to groundwater, data points will fall above the mixing line. If material is being removed from the system by processes such as uptake by biotic metabolic processes, data points will fall below the mixing line.

Dissolved Si represents a check on the model as this material is present in high concentration in groundwater, but is not a major component of fertilizer. In addition, Si is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 16 that when concentrations of Si are plotted as functions of salinity, data points from each of the sampling sites prescribe distinct linear arrays. Data points from Transect Sites 1and 2 lie on the irrigation lake water mixing line. Most of the data points for showing concentrations of Si from Transect Site 4 fall on the conservative mixing line created from water collected from an irrigation well. Data points from Site 3 prescribe a linear array above both mixing lines. Such a pattern suggests that the groundwater mixing with ocean water at the shoreline has slightly different composition between Sites 1-2, 3 and 4. These differences are likely a result of irrigation of the golf courses upslope from Transect Sites 1-2 with water from the irrigation lakes, while naturally occurring groundwater is mixing with ocean water off Transect Site 4. Even with these subtle differences between sampling locations, it appears that the groundwater endmembers from well No. 4 provides a valid representation of the effects of golf course operation on unaltered groundwater that enters the ocean following flow through the golf courses. Over the course of monitoring since 1995, the relationship between salinity and Si has remained nearly constant (Figure 17).

NO_3^- is the form of nitrogen most common in fertilizer mixes that are used for enhancing turf growth. As is the case for Si, there is a distinct difference in the mixing lines created for NO_3^- by connecting endpoint concentrations of open ocean water with well water and irrigation lake water (Figure 16). These differences are likely a result of uptake of NO_3^- by plants in the irrigation lake that results is substantially lower concentrations than in the irrigation well.

As with Si, the plots of NO_3^- versus salinity show that data points from each transect lie in a distinct linear array. Data points from Transect 4, which is considered the control site with no influence from the golf course, lie close to the irrigation lake mixing line. Such a position indicates that the source of NO_3^- entering the ocean at Transect 4 contains no subsidies from activities on land. Conversely, all of the data points from Transect 1and 3 lie above all of the mixing lines, indicating a subsidy of NO_3^- to the ocean from sources on land. In addition, the slopes of the lines created from the data points from Transects 1 and 3 are distinctly different, indicating different sources of NO_3^- at the two sites. Such is not the case at Site 2 where all of the concentrations of NO_3^- in the ocean samples are a result of mixing of natural groundwater (i.e., well water) and ocean water (Figure 16).

Site 1 is located directly downslope from the boundary between the Makena and Wailea Golf Courses, while Site 3 is located downslope from the area of the South course that is closest to the ocean. It is possible that the apparent subsidy of NO_3^- is a result of leaching of golf course fertilizers to the groundwater lens. In addition to the nearby golf courses, however, there are also newly constructed house lots with landscaping and lawns near the shoreline at Site 1. An old cesspool also remains from a house recently torn down that was directly inshore of Site 3. New construction of a multi-unit housing complex has been on-going at Site 3 for the past 6 months. As the mixing model reveals that the subsidies of NO_3^- in nearshore waters at Sites 1 and 3 are qualitatively different, the input at Site 3 may be associated with leaching of sewage nutrients from these residential features as well as leaching of golf course nutrients.

Linear regression of NO_3^- concentrations as a function of salinity for the present survey has a Y-intercept (concentration at a salinity equal to that of well water) of 313 µM at Site 1, 129 µM at Site 2, 734 µM at Site 3, and 120 µM at Site 4. Compared to the averaged concentration of NO_3^- measured in four irrigation wells for this survey (161 µM), there appears to be a subsidy to groundwater of at least 151 µM at Site 1, and 573 µM at Site 3. Thus, the concentration of NO_3^- in undiluted groundwater entering the ocean at Sites 1 and 3 are increased by about 2-fold and 4-fold, respectively over background concentrations in groundwater. These values are slightly lower at Site 1 and slightly higher at Site 3 than the subsidies calculated from the sample concentrations from the previous surveys in March and November 2004. Hence, these subsidies may be slightly increasing with time at this location, while decreasing at Site 1. It is also apparent in Figure 17 that the slope of the NO_3^- data points as functions of salinity at Site 3 are the steepest that have been measured during the course of monitoring since 1995. Mixing analyses also indicate that groundwater from Sites 2 and 4 has not shown a significant increase in the concentration of NO_3^- compared to naturally occurring groundwater over the course of monitoring (Figure 17).

While the regression calculations reported above indicate substantial subsidies of NO_3^- to groundwater, it is important to note that with respect to potential environmental effects, it is nutrient availability in the water column that is of primary importance. While projected elevated concentrations of NO_3^- in groundwater reaching the shoreline may be the result of activities on land, the actual concentration of NO_3^- in nearshore waters at Site 3 does not differ greatly from areas with no subsidy. The average concentration of NO_3^- of samples collected within 50 m of the shoreline at Site 3 is 7.7 µM compared to 5.4 µM at Control Site 4.

Site 1 has also been used as a monitoring station for a similar evaluation of the effects of the Wailea Golf Courses on water chemistry since 1989. The lowest concentrations of NO_3^- relative to salinity at Site 1 occurred during the initial two years of study, with subsequent higher concentrations from 1992 through the last survey in 2001. Hence, there appears to have been an increase of NO_3^- in nearshore waters that was not occurring in 1989-1991.

Completion of the Wailea Gold Course occurred in December 1993, while completion of the Makena North Course occurred in November 1993. As the southern region of the Wailea Course and the northern part of the Makena Course overlap in the makai-mauka direction landward of ocean sampling Site 1, the increased concentrations of NO_3^- may be a result of leaching of fertilizer materials from the combined golf courses to groundwater that enters the ocean in the sampling area.

Similarly, the new location of sampling Site 3 is adjacent to the portion of the Makena Course extends to within approximately 50 m of the shoreline. This section of the course was recently grassed with new turf. In order to expedite rapid grow-in of the turn, maximal rates of fertilization are temporarily employed. Such rates of fertilizer application may be the source of the high levels of NO_3^- detected in offshore waters adjacent to the golf course. This site has only been investigated since August 2002 with similar results showing high levels of NO_3^- in the nearshore zone. Future time-series surveys will reveal if there is a downward trend in NO_3^- concentration with the decrease in fertilizer application on the golf holes adjacent to sampling Site 3.

While the data reveal a long-term subsidy to the concentration of NO_3^- in groundwater at Sites 1 and 3, it does not appear that there has been any adverse effect to the biota offshore of this area. Because of the linear relationship of the concentrations of NO_3^- as functions of salinity, there is no indication of uptake of this material in the marine environment. Such lack of uptake indicates that the nutrients are not being removed from the water column by metabolic reactions that could change the composition of the marine environment. Rather, the nutrients entering the ocean through groundwater efflux appear to be dispersed solely by physical mixing processes. As a result, it does not appear that the increased nutrients are causing any alteration in biological community composition or function.

Similar situations have also been observed in other locales in the Hawaiian islands where nutrient subsidies from golf course leaching result in excess NO_3^- in the nearshore zone. At Keauhou Bay on the Big Island, it was shown that owing to the distinct vertical stratification in the nearshore zone, the excess nutrients never come into contact with benthic communities, thereby limiting the potential for increased uptake by benthic algae. In addition, the residence time of the high nutrient water was short enough within the embayment to preclude phytoplankton blooms. As a result, while NO_3^- concentrations doubled as a result of golf course leaching for a period of at least several years, there was no detectable negative effect to the marine environment (Dollar and Atkinson 1992). Owing to the unrestricted nature of circulation and mixing off the Makena project (no confined embayment) it is reasonable to assume that the excess NO_3^- subsidies that are apparent in the present study will not result in alteration to biological communities.

Inspection of the offshore area reveals an apparently healthy coral reef that does not appear to exhibit any negative effects from nutrient loading. There are no areas where excessive algal growth is presently occurring. The mean concentration of Chl *a* in surface waters within 50 m of the shoreline off of Site 3 (0.65 µg/L), was the lowest of any of the four transects, and was nearly one-third the values that occurred off Control Site 4 (1.76 µg/L), which displayed no subsidy of NO_3^-. The lower values of Chl *a* indicate that plankton biomass is not elevated in the areas of highest nutrient subsidy to groundwater. Continued monitoring will indicate if this trend continues.

It is also important to note that there is no subsidy of NO_3^- at Site 2 (Makena Landing) that was impacted by the flash flood in 1999. While turbidity in this area was affected on a sustained basis (at least for a year following the flood), there is no increase in the form of nitrogen associated with golf course fertilization.

The other form of dissolved inorganic nitrogen, NH_4^+, does not show a linear pattern of distribution with respect to salinity for either the June 2005 survey (Figure 16) or the entire monitoring program (Figure 18). Many of the samples with near oceanic salinity also displayed the highest concentrations of NH_4^+. The lack of a correlation between salinity and concentration of NH_4^+ suggests that this form of nitrogen is not present in the marine environment as a result of mixing from groundwater sources. Rather, NH_4^+ is generated by natural biotic activity in the ocean waters off Makena. It is also interesting to note that the conservative mixing line for NH_4^+ constructed from the endpoint concentration from irrigation lake 10, composed of well water and sewage effluent, has a substantially steeper slope than the mixing line constructed from water from irrigation Well 4.

PO_4^{3-} is also a major component of fertilizer, but is usually not found to leach to groundwater to the extent of NO_3^-, owing to a high absorptive affinity of phosphorus in soils. Data points for PO_4^{3-} from the June 2005 survey do not show a distinct linear trend with respect to salinity at any of the sites. Some of the highest concentrations of PO_4^{3-} occurred at the Control Site (Figure 16). The elevated NO_3^- at Sites 1 and 3, which appear to be influenced by golf course and residential landscaping, is not reflected in similar subsidies of PO_4^{3-}. Examination of the entire data set indicates that the highest concentrations of PO_4^{3-} occur at Control Site 4, which is deemed beyond the influence of the golf course. Over the entire monitoring program, the data set shows the same consistent trend (Figure 18).

D. Compliance with DOH Standards

Tables 1 and 2 also show samples that exceed DOH water quality standards for open coastal waters under "wet" and "dry" conditions. These criteria are applied depending upon whether the area is likely to receive less than (dry) or greater than (wet) 3 million gallons of groundwater input per mile per day. As it is not readily possible to accurately estimate groundwater and surface water discharge, both wet and dry standards are considered. DOH standards include specific criteria for three situations; criteria that are not to be exceeded during either 10% or 2% of the time, and criteria that are not to be exceeded by the geometric mean of samples. With only fifteen samples collected to date from each sampling station, comparison of the 10% or 2% of the time criteria for any sample is not statistically meaningful. However, comparing sample concentrations to these criteria provide an indication of whether water quality is near the stated specific criteria.

Boxed values in Tables 1 and 2 show instances where measurements exceed the DOH standards under dry conditions, while boxed and shaded values show instances where measurements exceed DOH standards under wet conditions. During the June 2005 survey, concentrations of NO_3^- in samples collected within 10 m of the shoreline on all four transects, including Control Site 4, exceeded the 10% "wet" standards. Concentrations of NO_3^- also exceeded the wet standards along the remainder of Transect 1 and to 50 m offshore at Station 3 (Table 1). From the preceding discussion of conservative mixing, it is apparent that natural input of groundwater to the nearshore zone can substantially raise the concentrations of NO_3^- to values exceeding DOH standards without anthropogenic subsidies. While there is no statistically significant increase of NO_3^- over natural groundwater input at Sites 2 and 4, a few samples from both these areas exceed the DOH limits. This is especially important at Control Site 4, where there is no influence from the golf courses. Thus, it appears that input of natural groundwater (and possible non-Resort activity) can result in ocean water quality measurements that can be interpreted to exceed DOH standards.

In addition, results from the June 2005 survey indicated that eight measurements of NH_4^+, sixteen measurements of TN, four measurements of turbidity and all but nineteen measurements of Chl *a* exceeded the 10% DOH criteria under dry conditions. No measurements of TP exceeded the 10% dry standards during June 2005. When compared under wet conditions, only three measurements of NH_4^+, nine measurements of TN and fifteen measurements of Chl *a* were exceeded.

Tables 3 and 4 show geometric means of samples collected at the same locations during the fifteen increments of the monitoring program at all four sites. Also shown in these tables are the samples that exceed the DOH geometric mean limits for open coastal waters under "dry" (boxed) and "wet" (boxed and shaded) conditions. For NO_3^-, NH_4^+, and TN numerous dry and wet standards were exceeded. Five samples of TP, eighteen samples of turbidity exceeded the dry standards. All samples exceed the geometric mean standards for Chl *a*.

Site 4 is considered a control transect, in that it is not located offshore of a golf course. However, it can be seen in Tables 3 and 4 that the number of samples that exceed geometric mean criteria at Site 4 are comparable to the other three sites, all of which are located downslope from the Makena Resort. Hence, it appears that the Resort activities, including golf courses cannot be attributed as the sole (or even major) factor causing water quality to exceed geometric mean standards.

IV. SUMMARY

- The fifteenth phase of water chemistry monitoring of the nearshore ocean off the Makena Resort was carried out on June 19, 2005. Fifty ocean water samples were collected on three transects spaced along the project ocean frontage. One transect was located outside of the Makena Resort area in order to serve as a control site. Site 1 was located at the northern boundary of the project, Site 2 was located near the central part of the Makena North Golf Course in the center of Makena Bay, Site 3 was downslope from the part of Makena South Golf Course that comes closest to the shoreline, and Control Site 4 was located to the south of Makena Resort off the 'Ahihi-Kina`u Natural Area Reserve. Sampling transects extended from the shoreline out to the open coastal ocean. Water samples were analyzed for chemical criteria specified by DOH water quality standards, as well as several additional criteria. In addition, water samples were collected from seven irrigation wells and two irrigation lakes located on the Makena Golf Courses.

- Water chemistry constituents that occur in high concentration in groundwater (Si, NO_3^- and PO_4^{3-}) displayed distinct horizontal gradients with high concentrations nearest to shore and decreasing concentrations moving seaward. Based on salinity, groundwater input was greatest at Sites 1, 3 and 4, and to a lesser extent at Site 2. As Site 4 was not located in the vicinity of the Makena Resort, it is apparent that groundwater input is not solely a response to land usage.

- Slight vertical stratification of the water column was evident beyond 10 m of the shoreline at Sites 1, 2 and 3, but not at Site 4. Vertical and horizontal patterns of distribution indicate that physical mixing processes generated by wind, waves and currents were not sufficient for complete mixing of the water column at these sites.

- Turbidity and Chl *a* were elevated near the shoreline at all four sites, as has been the case in all previous surveys. Site 2 is located at the point where sediment-laden storm water runoff entered the ocean following a flash flood in October 1999. While the highly turbid conditions associated with the runoff event are no longer evident, normal processes of circulation (tidal exchange, wave mixing) and the silt/sand bottom result in slightly more turbid conditions in Makena Bay (Site 2) compared to the other sampling sites that occur in areas with predominantly hard reef substrata.

- Most water chemistry constituents that do not occur in high concentrations in groundwater did not display any recognizable horizontal or vertical trends.

- Scaling nutrient concentrations to salinity indicates that there were measurable subsidies of NO_3^- to the groundwater that enters the nearshore ocean at Sites 1 and Site 3. The subsidy substantially increases the concentration of NO_3^- with respect to salinity in groundwater flowing to the ocean compared to natural groundwater. The area shoreward of Site 1 includes an overlap of the southern part of the Wailea Gold Course and the northern part of the Makena North Course, as well as residential development. Site 3 is directly downslope from the Makena South Course in an area that was recently planted with new turf, which requires maximal fertilization to expedite growth. In addition, a cesspool remains from a house that was recently torn down lies directly inshore from Site 3. Hence, the subsidies of NO_3^- noted at Sites 1 and 3 may result from a combination of sources. While the scaling of nutrient concentration to salinity indicates that the projected concentration of NO_3^- in undiluted groundwater is subsidized by inputs from land uses, the actual concentrations of NO_3^- in the ocean at Site 3 are only slightly elevated over the control site.

- Similar subsidies of NO_3^- were not evident at Site 2, off the Makena North Course (Makena Bay). Thus, other sources besides golf course fertilizers may be contributing to the nutrient subsidies. If the subsidy of NO_3^- is a result of construction and operation of the existing golf courses, future monitoring surveys should indicate if the leaching of NO_3^- to the ocean is a temporary phenomenon that decreases with time, or is a continuing pattern.

- There is no subsidy of PO_4^{3-} corresponding to the subsidy of NO_3^- at Site 1. However, the highest concentrations of PO_4^{3-} were measured in nearshore samples at Site 4. As Site 4 is a control, the slightly elevated concentrations of PO_4^{3-} are originating from sources not associated with the Makena Resort.

- Comparing water chemistry parameters to DOH standards revealed that numerous measurements of NO_3^-, a few measurements of NH_4^+, TN, and turbidity and nearly all measurements of Chl *a* exceeded the DOH "not to exceed more than 10% of the time" criteria for dry and wet conditions of open coastal waters. No measurements of TP exceeded the DOH standards during this survey. It is apparent that the concentrations of NO_3^- in nearshore marine waters that contains a mixture of seawater and natural groundwater may exceed DOH criteria with no subsidies from human activities on land. Numerous values of NO_3^-, NH_4^+, TP, TN, turbidity and all measurements of Chl *a* exceeded specified limits for geometric means. Such exceedances occurred at all survey sites, including the control site that was far from any golf course influence.

- As in past surveys, there appears to be a definite input of nutrients (NO_3^-) to groundwater that enters the nearshore ocean at sampling sites downslope from parts of the Makena Resort, as well as other residential properties. However, this input has not increased substantially relative to previous surveys, and does not appear to be detrimental to marine community structure.

- The next phase of the Makena Resort monitoring program is scheduled for the second half of 2005.

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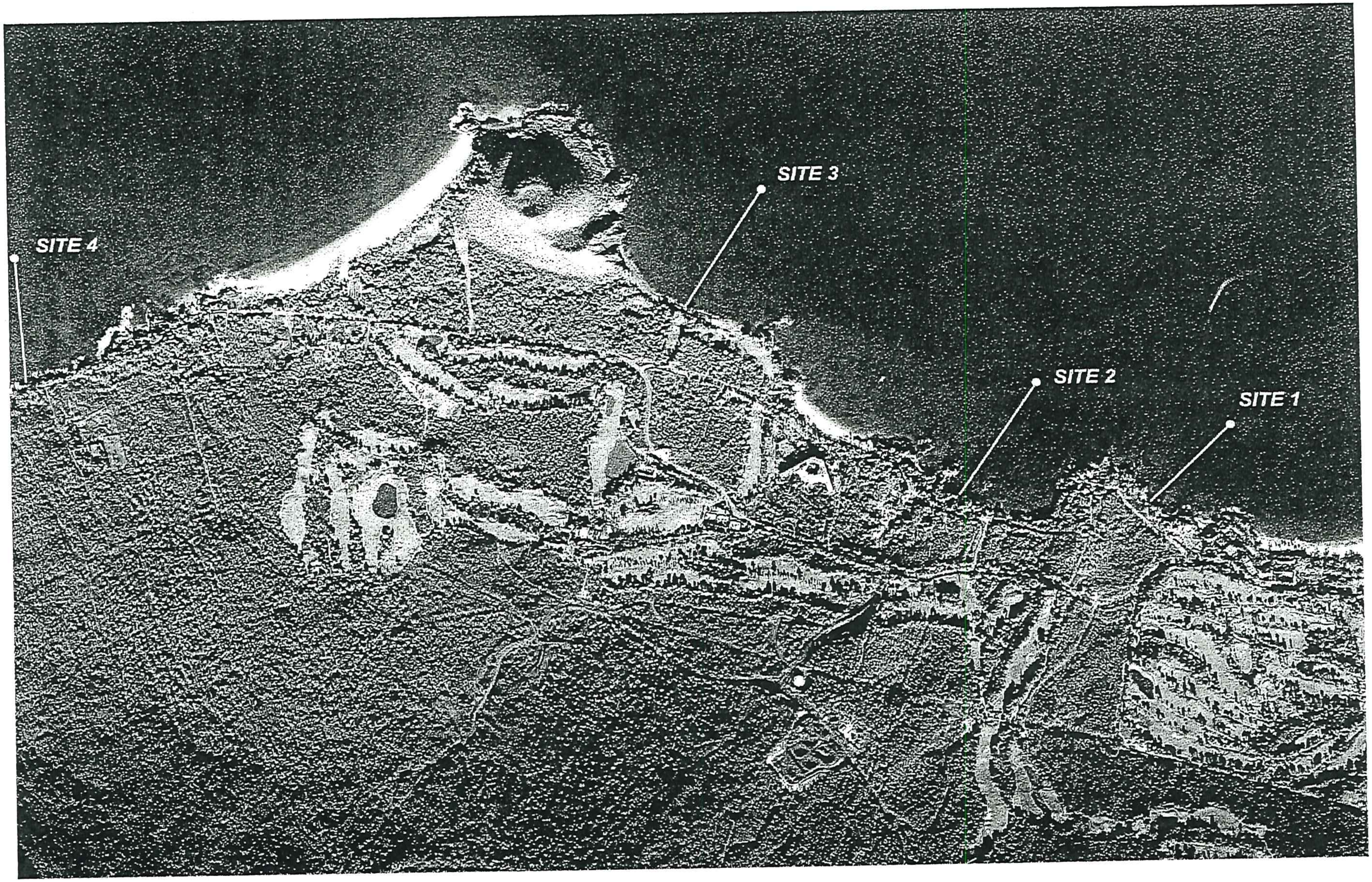

FIGURE 1. Aerial photograph of Makena Golf Courses on Southwest coastline of Maui showing locations of four ocean water sampling sites.

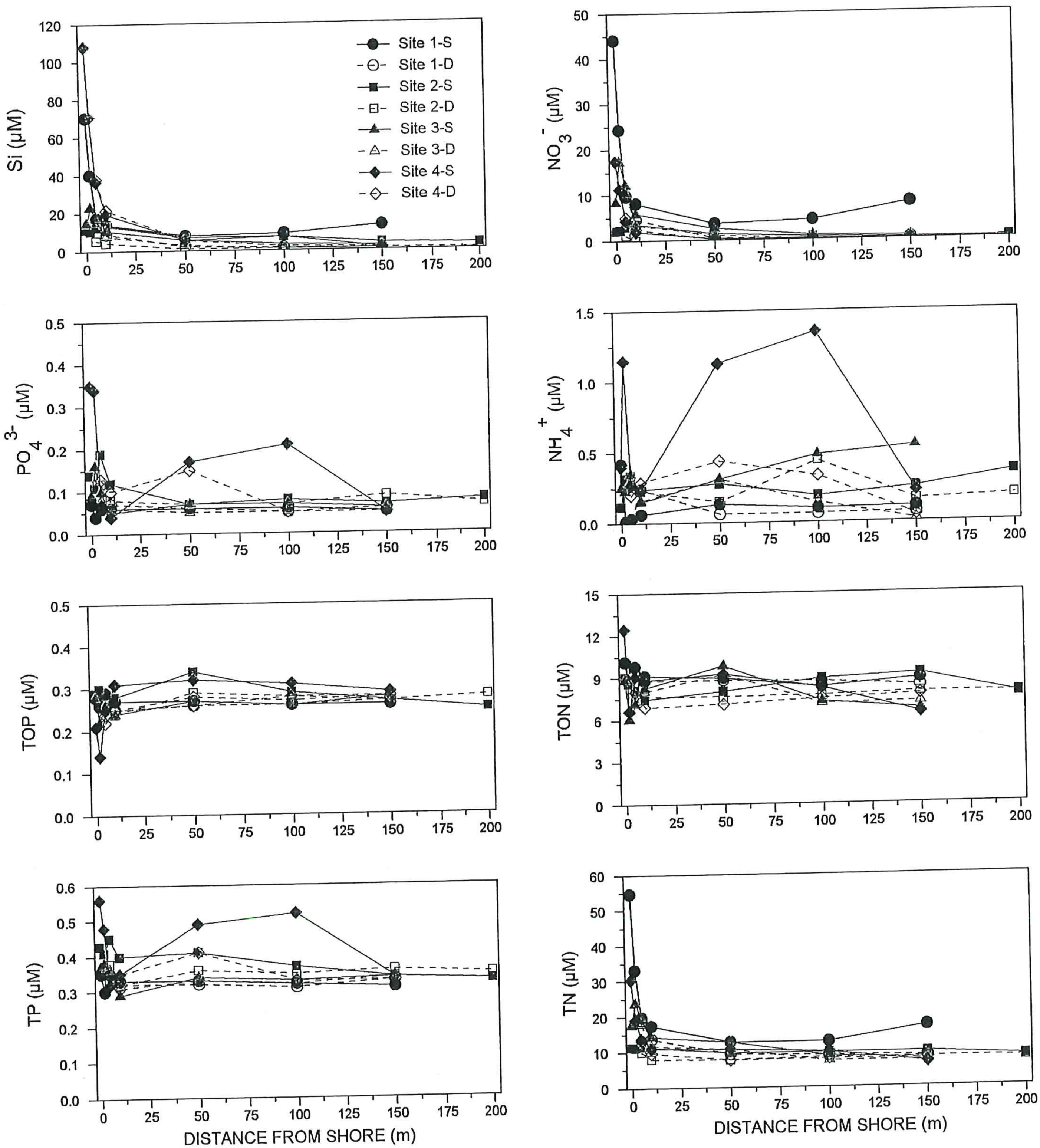

FIGURE 2. Plots of dissolved nutrients in surface (S) and deep (D) samples collected on June 19, 2005 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

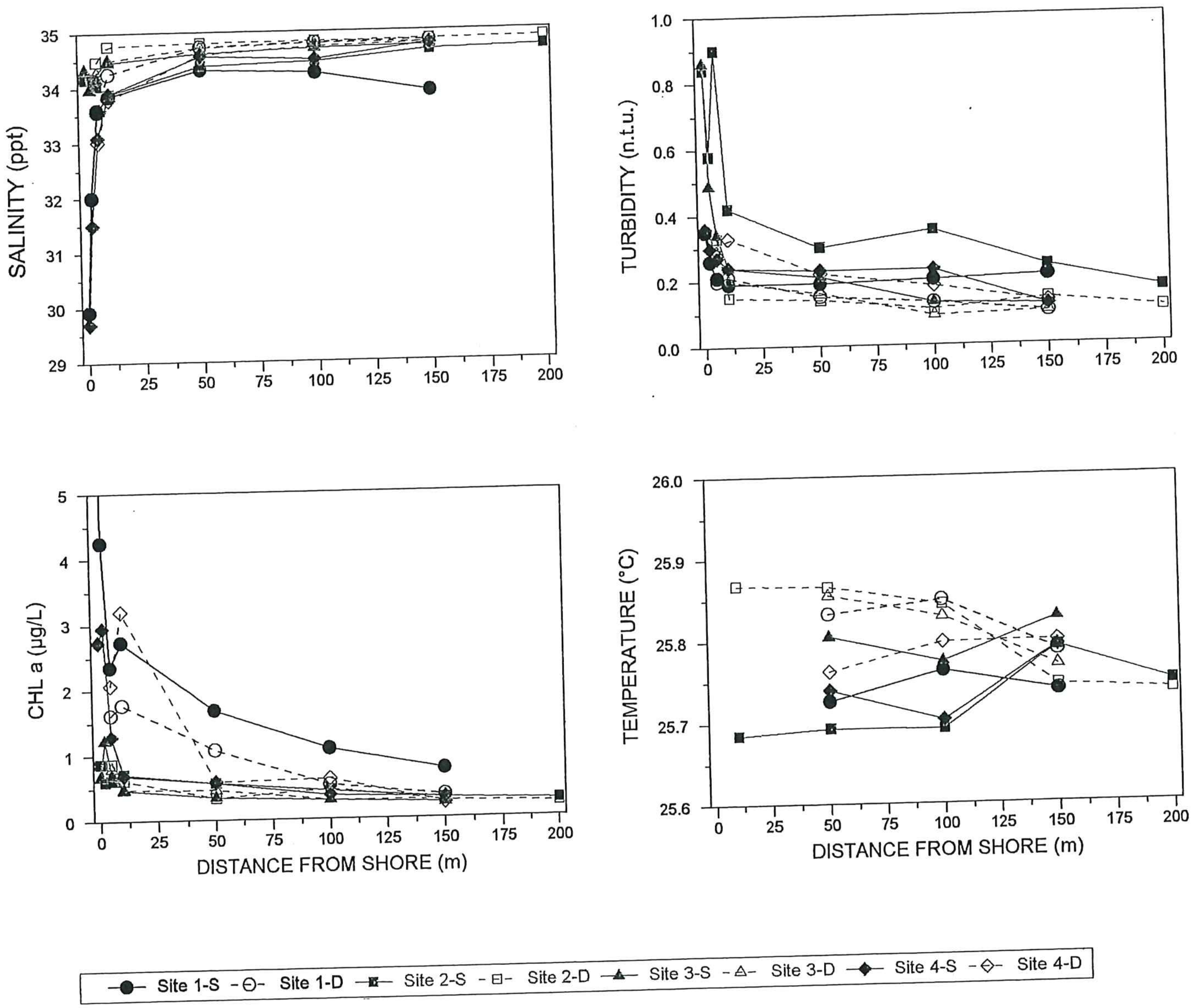

FIGURE 3. Plots of water chemistry constituents in surface (S) and deep (D) samples collected on June 19, 2005 as a function of distance from the shoreline in the vicinity of Makena Resort. Note: temperature data was not recorded for nearshore samples at Sites 1, 3 and 4. For site locations, see Figure 1.

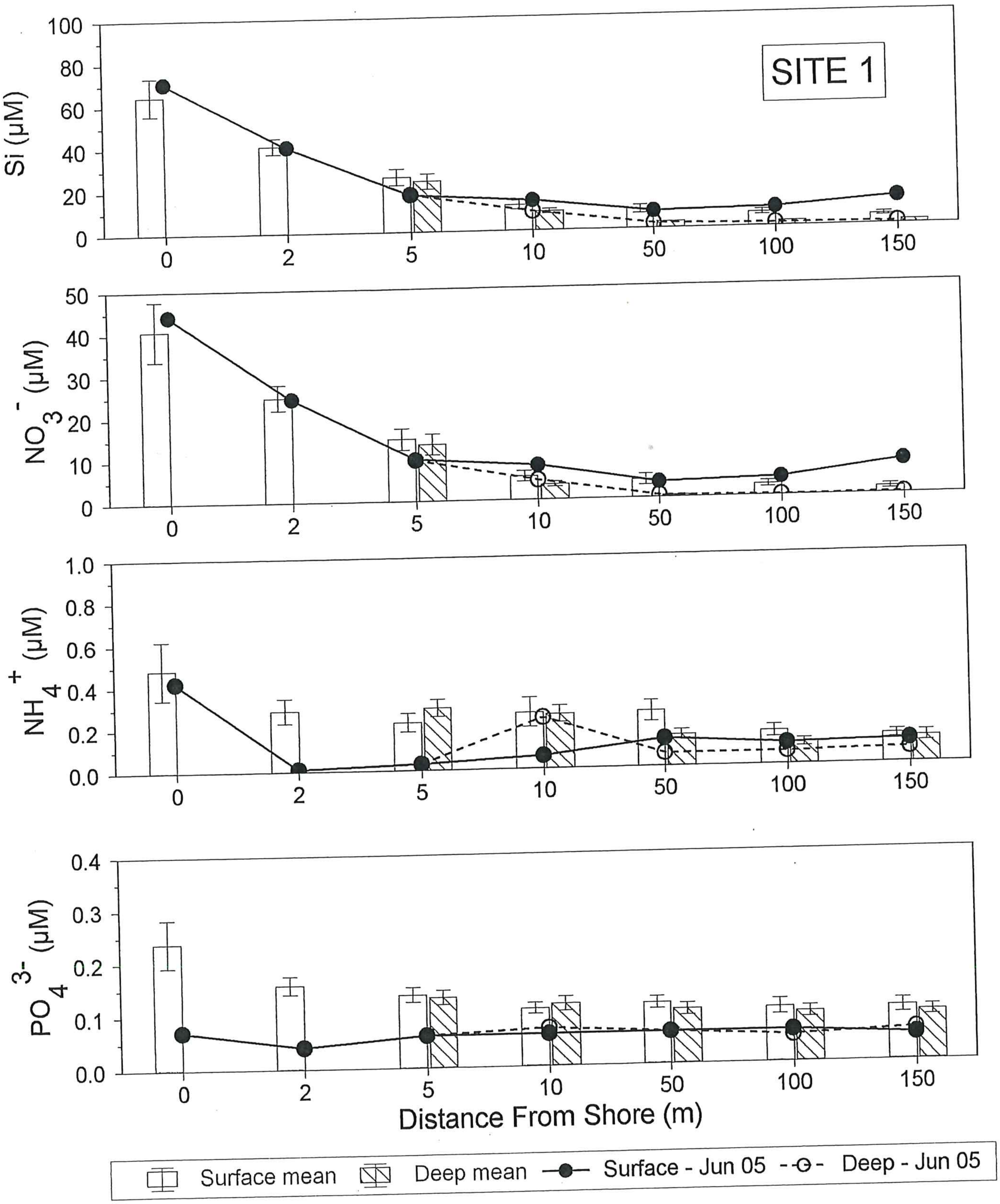

FIGURE 4. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

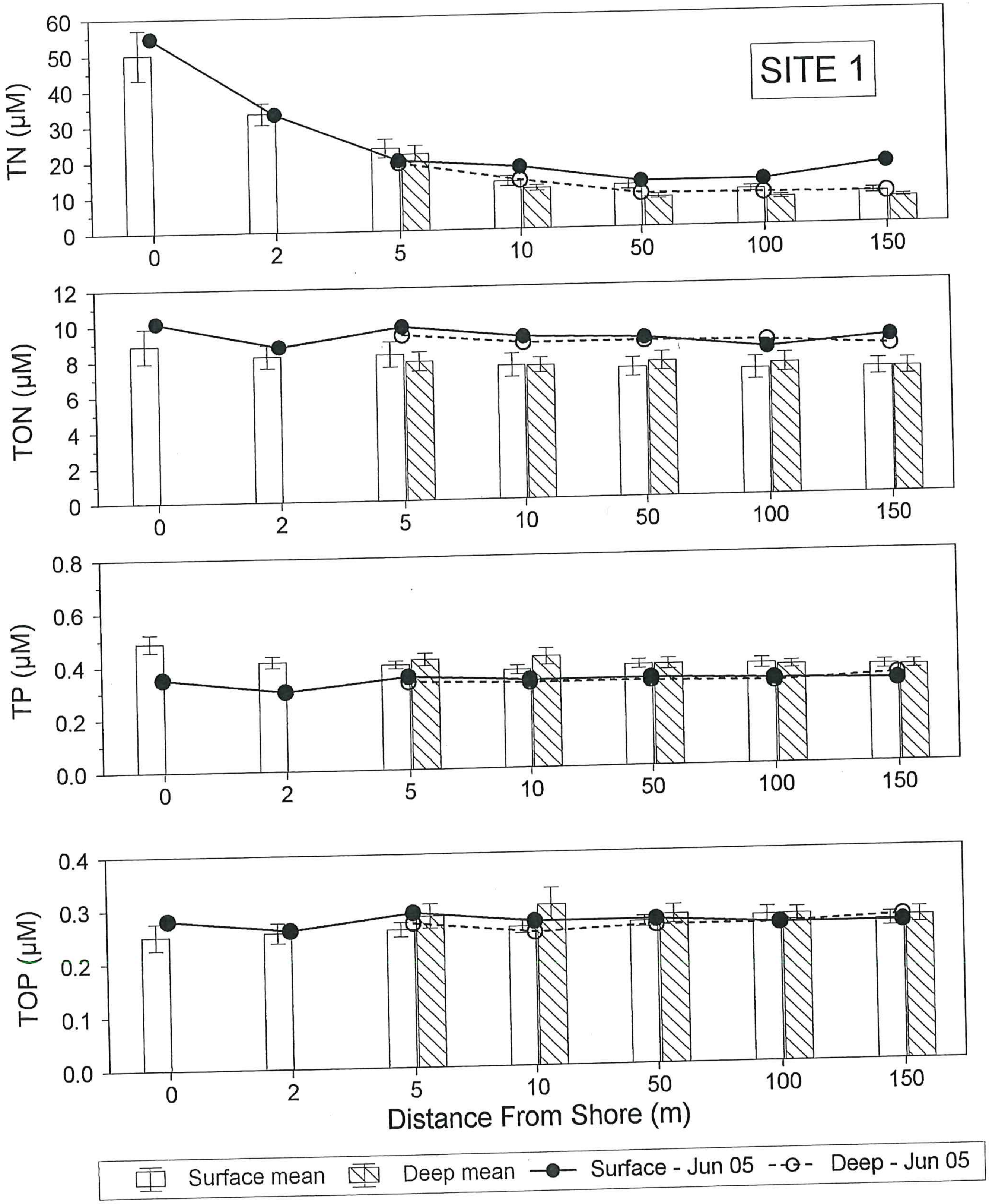

FIGURE 5. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

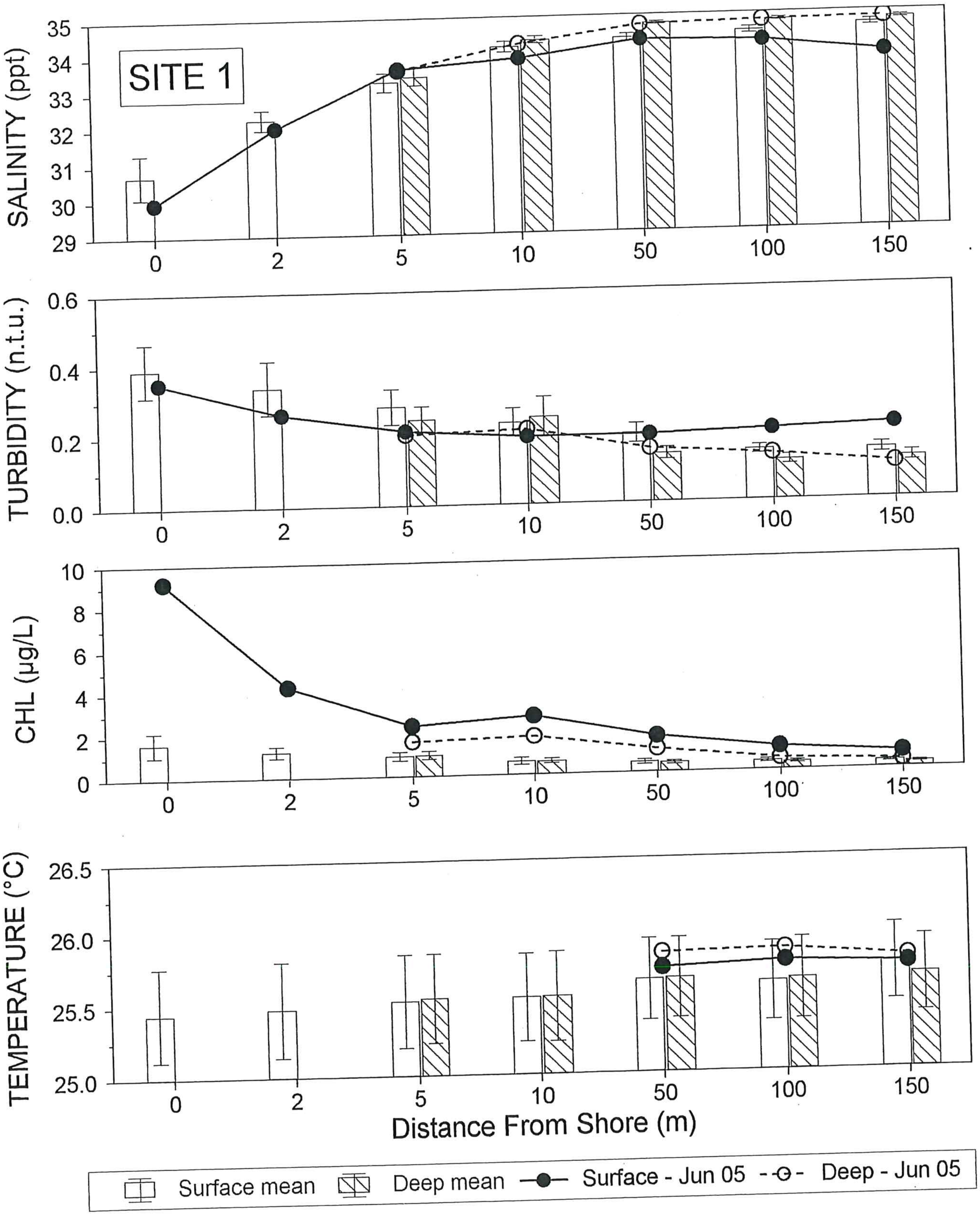

FIGURE 6. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

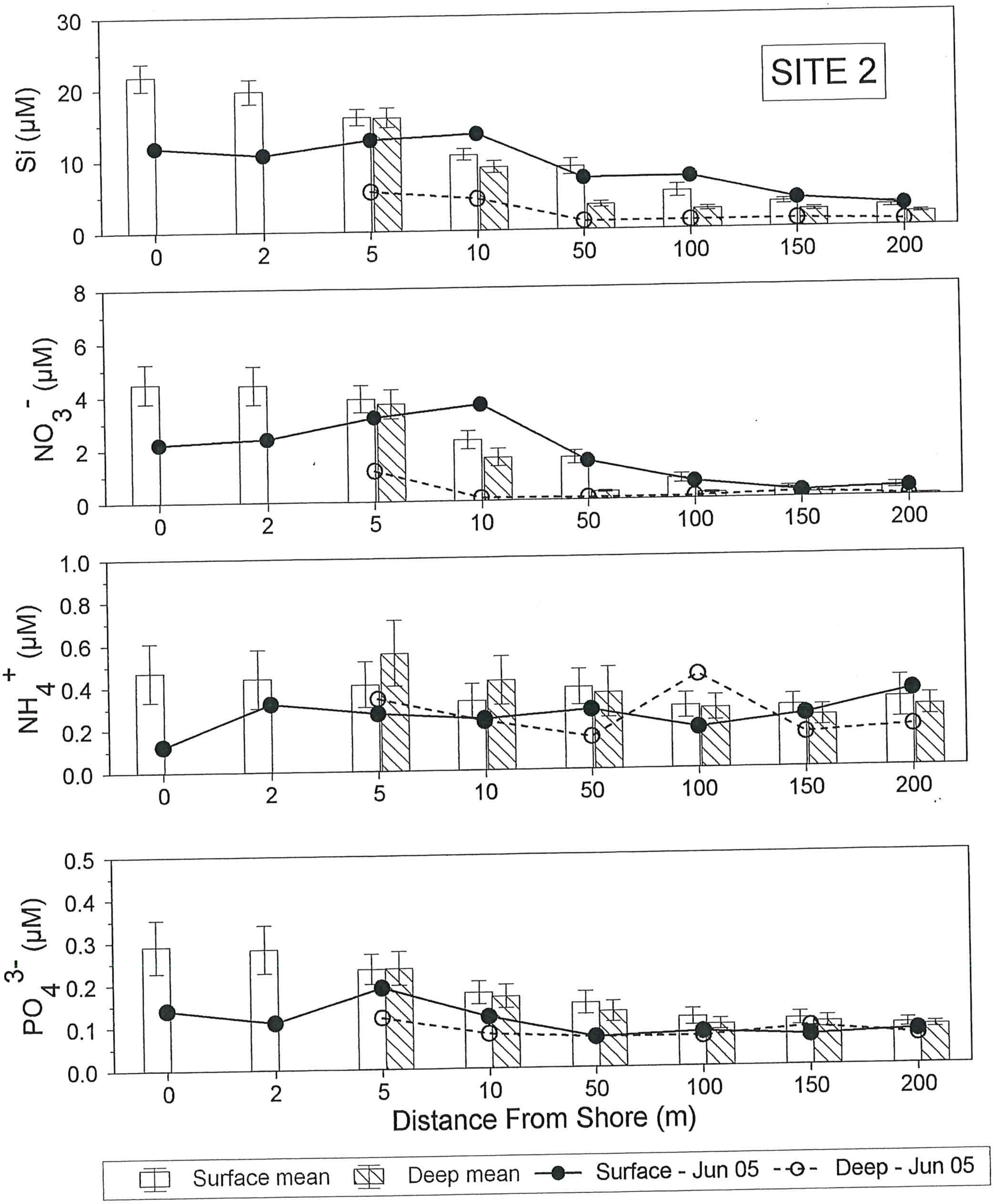

FIGURE 7. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

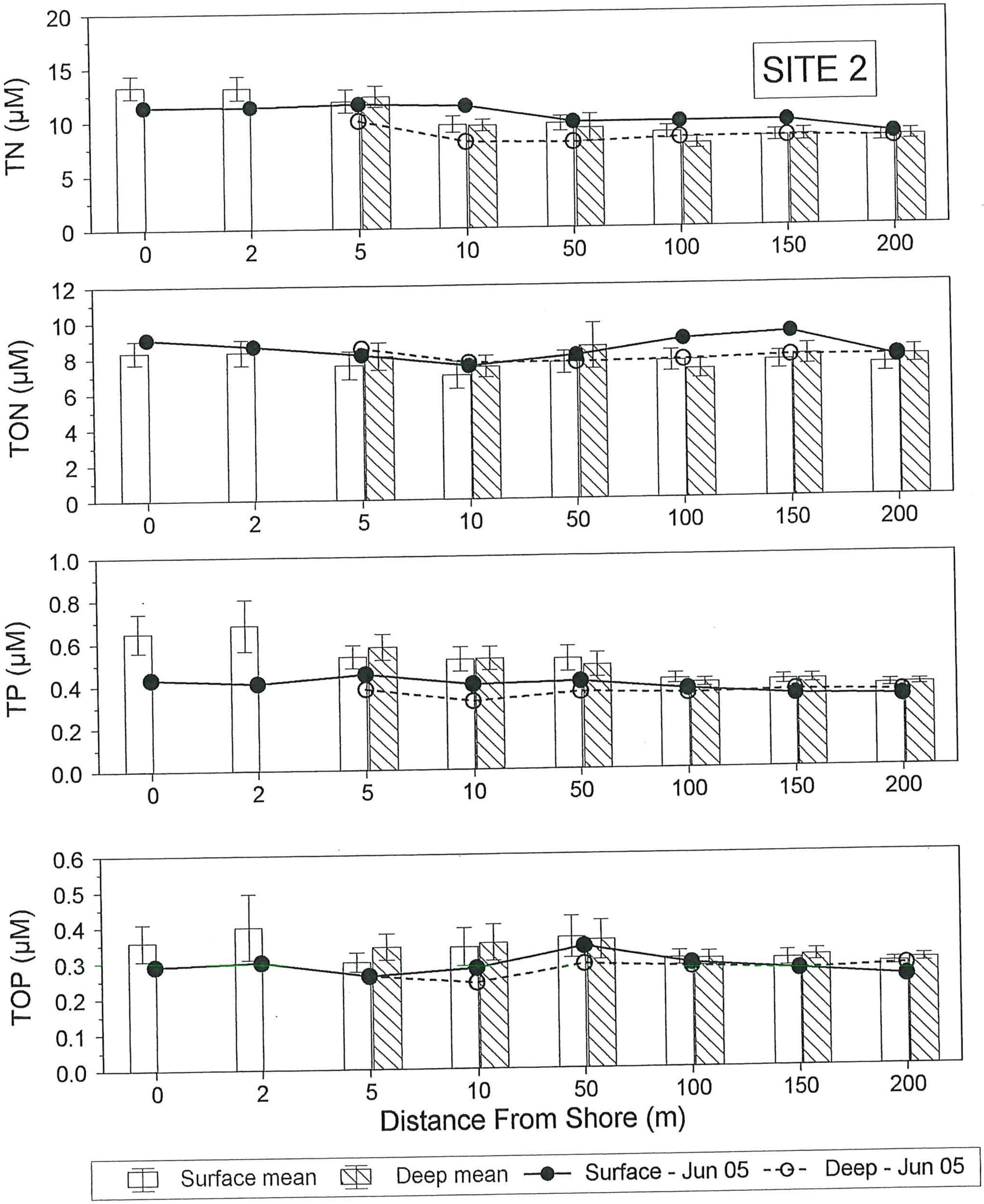

FIGURE 8. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

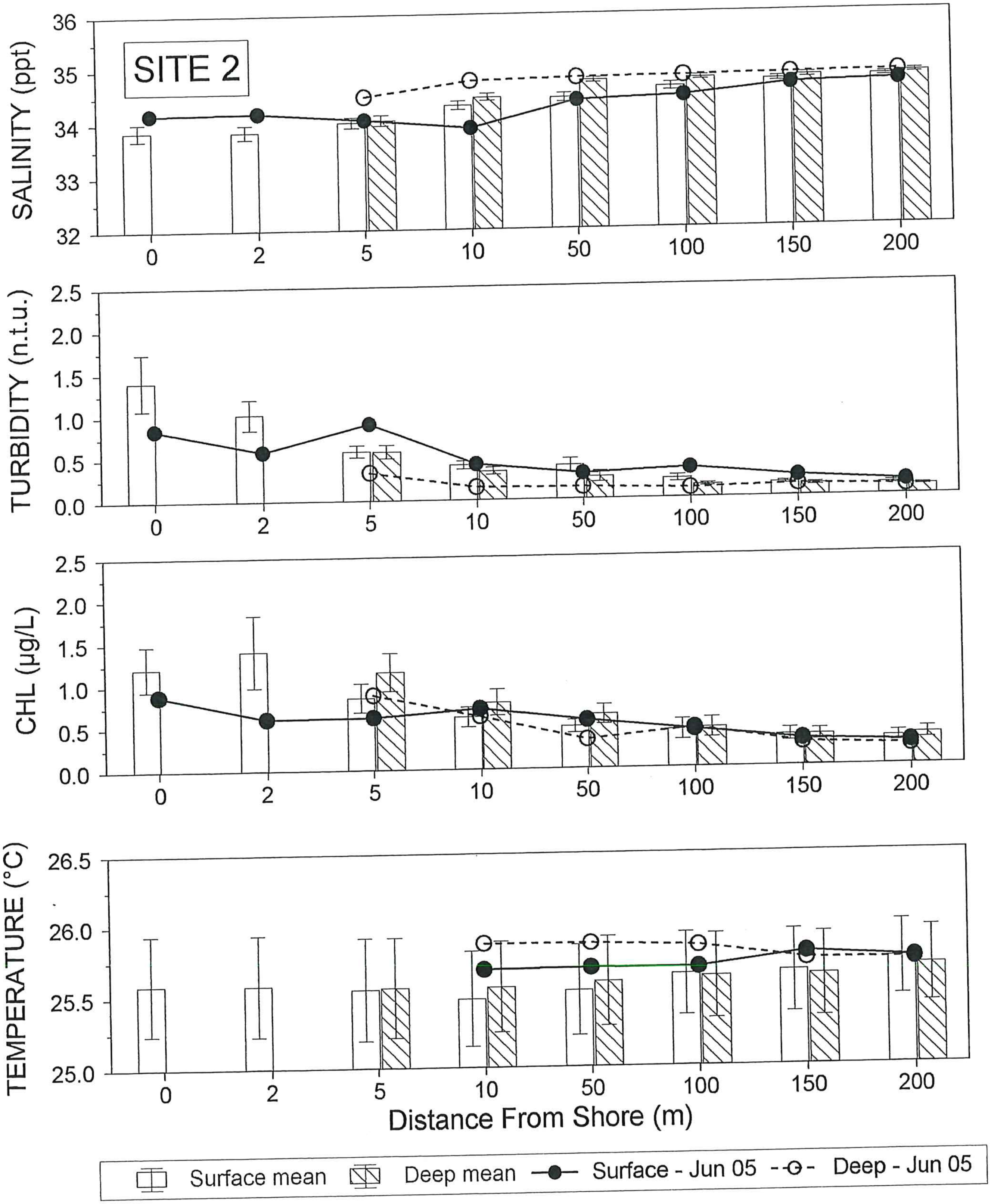

FIGURE 9. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey,bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

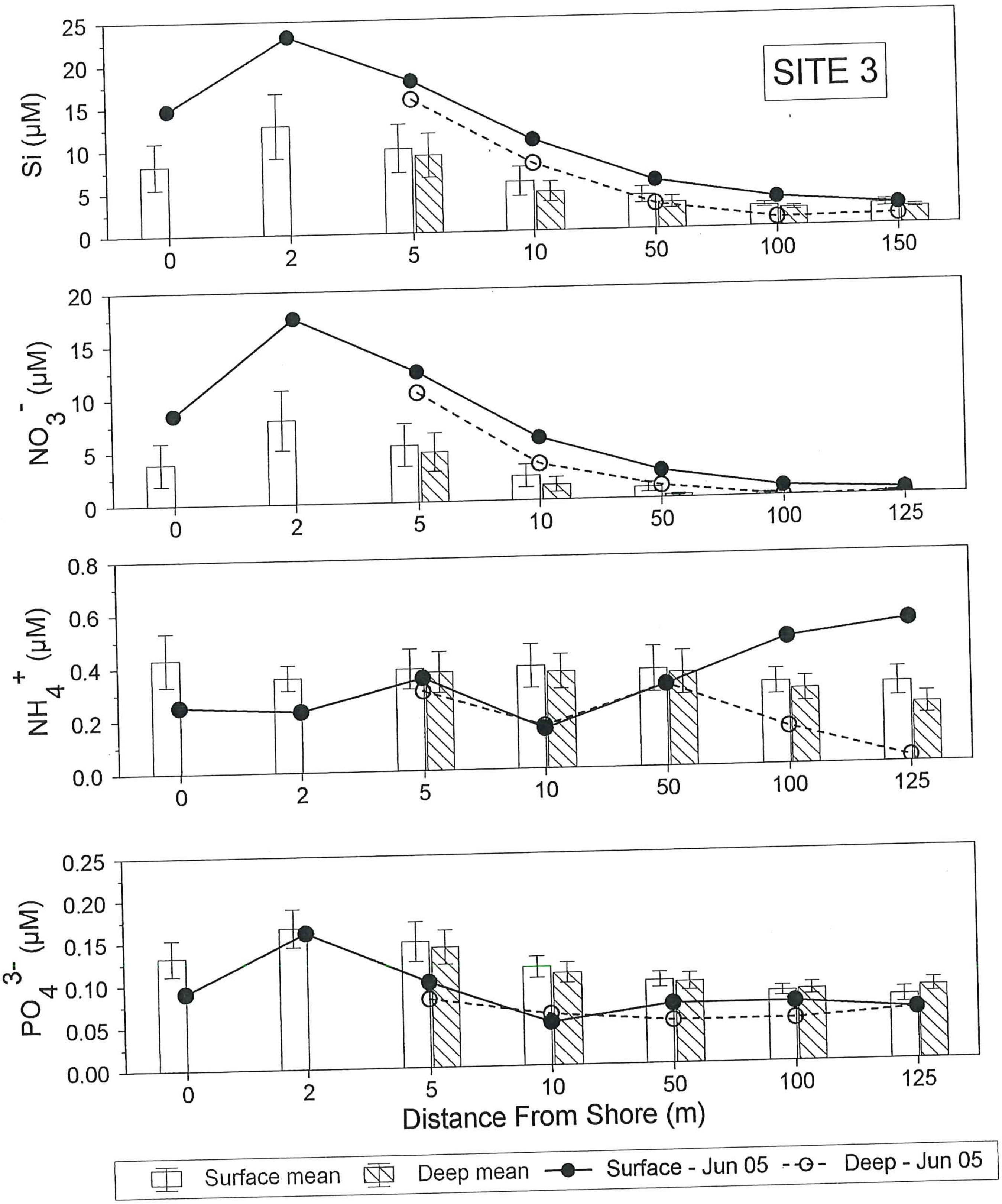

FIGURE 10. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

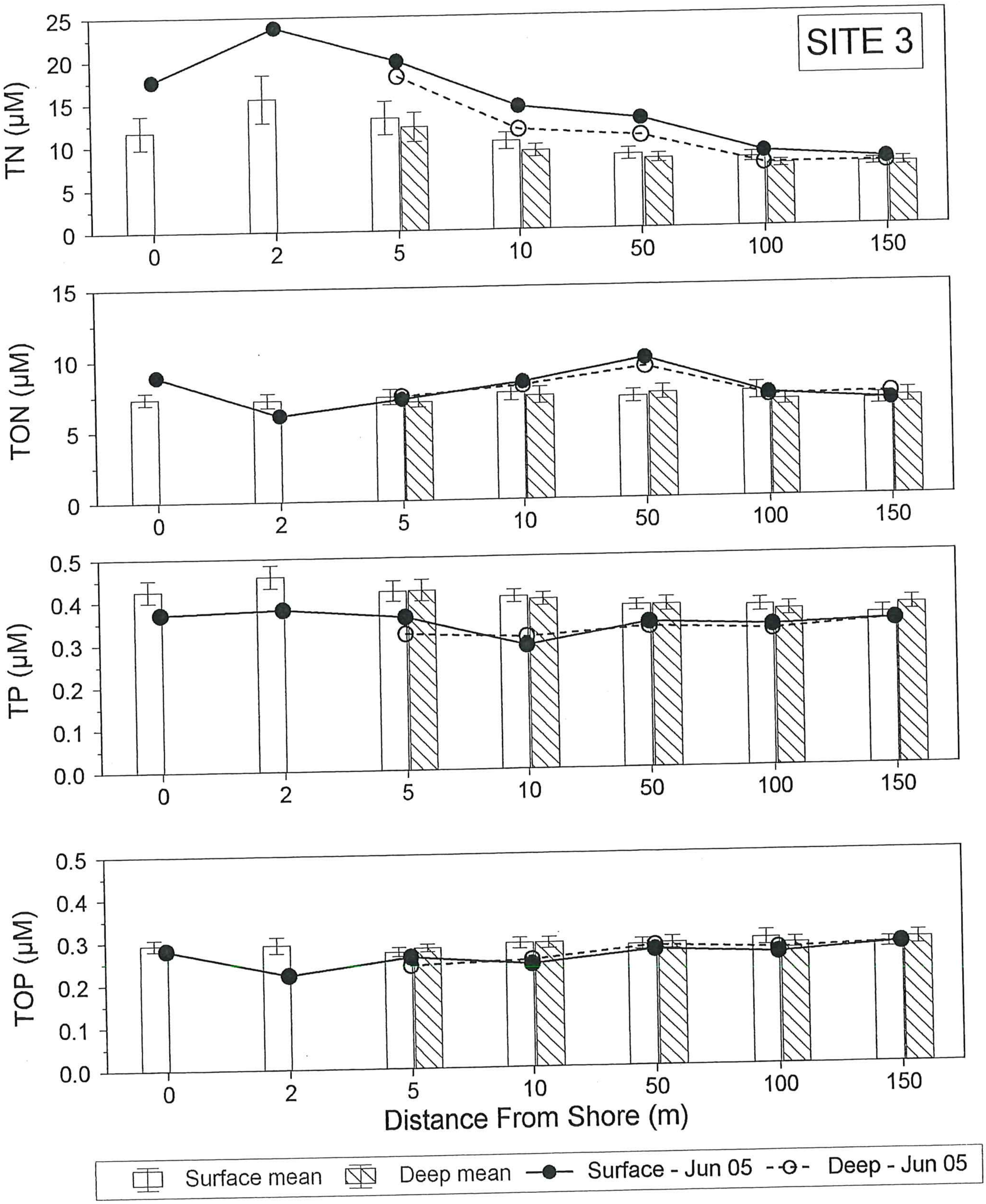

FIGURE 11. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

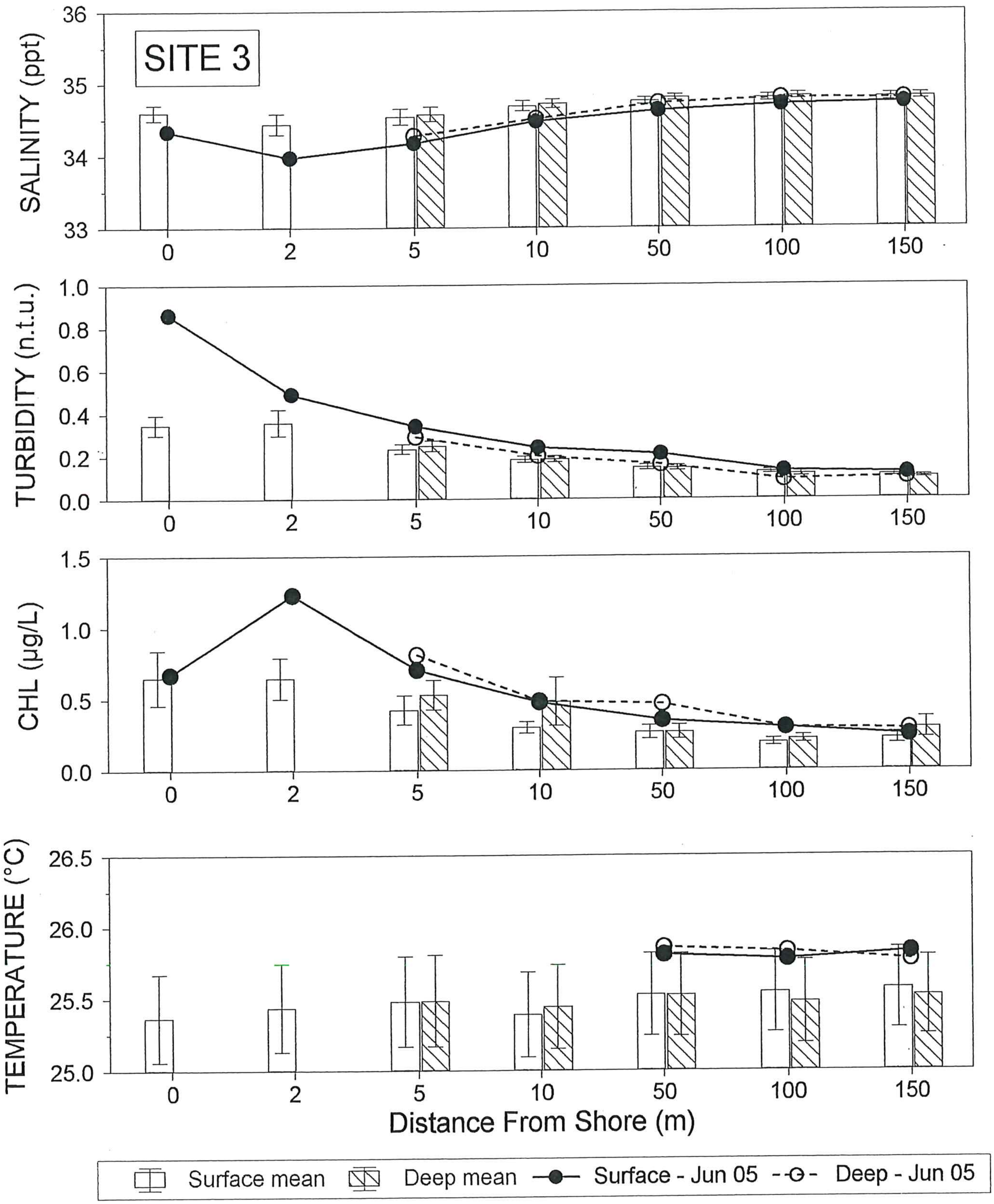

FIGURE 12. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

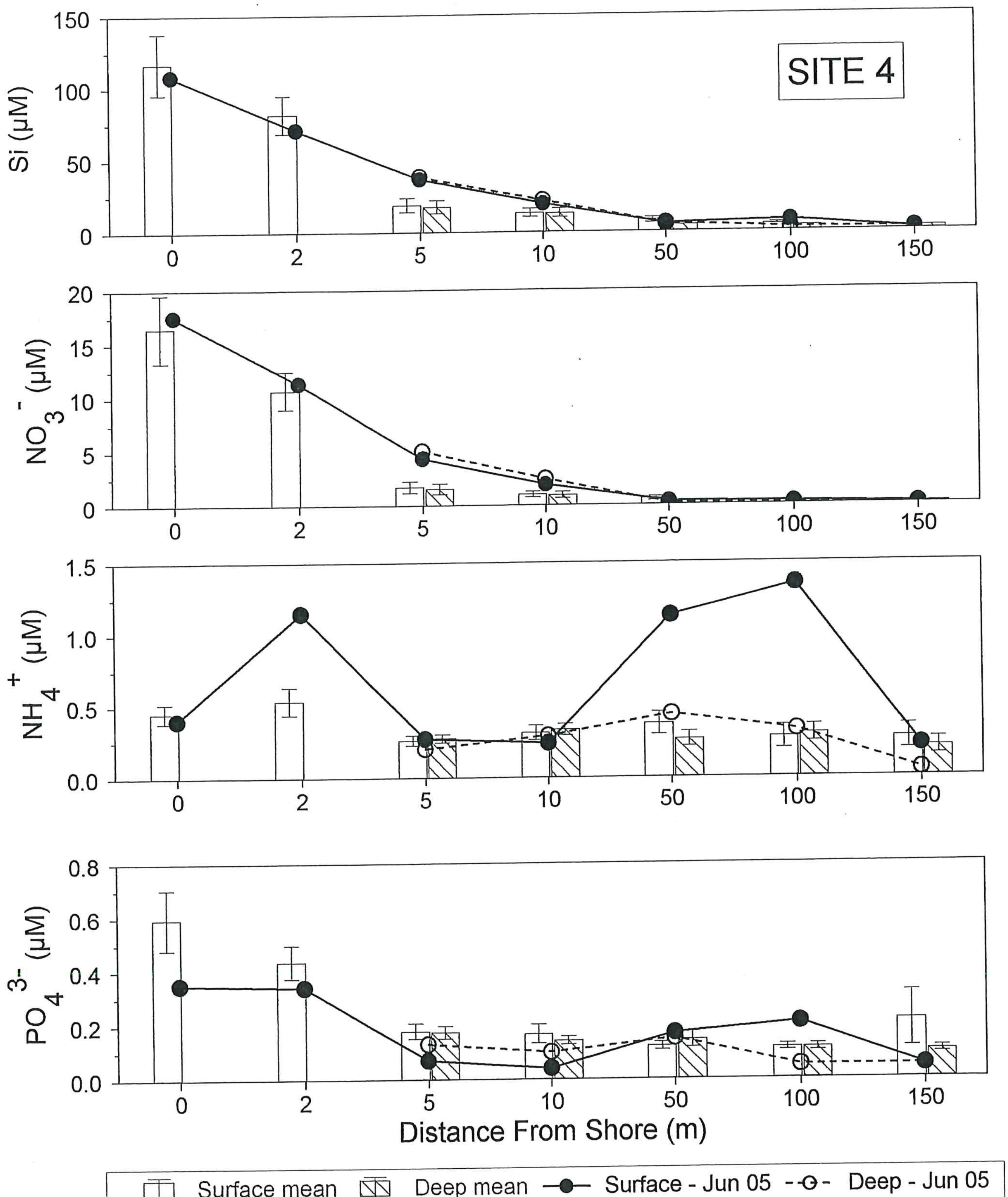

FIGURE 13. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. Note Y-axis scale break for Si and NO3. For site location, see Figure 1.

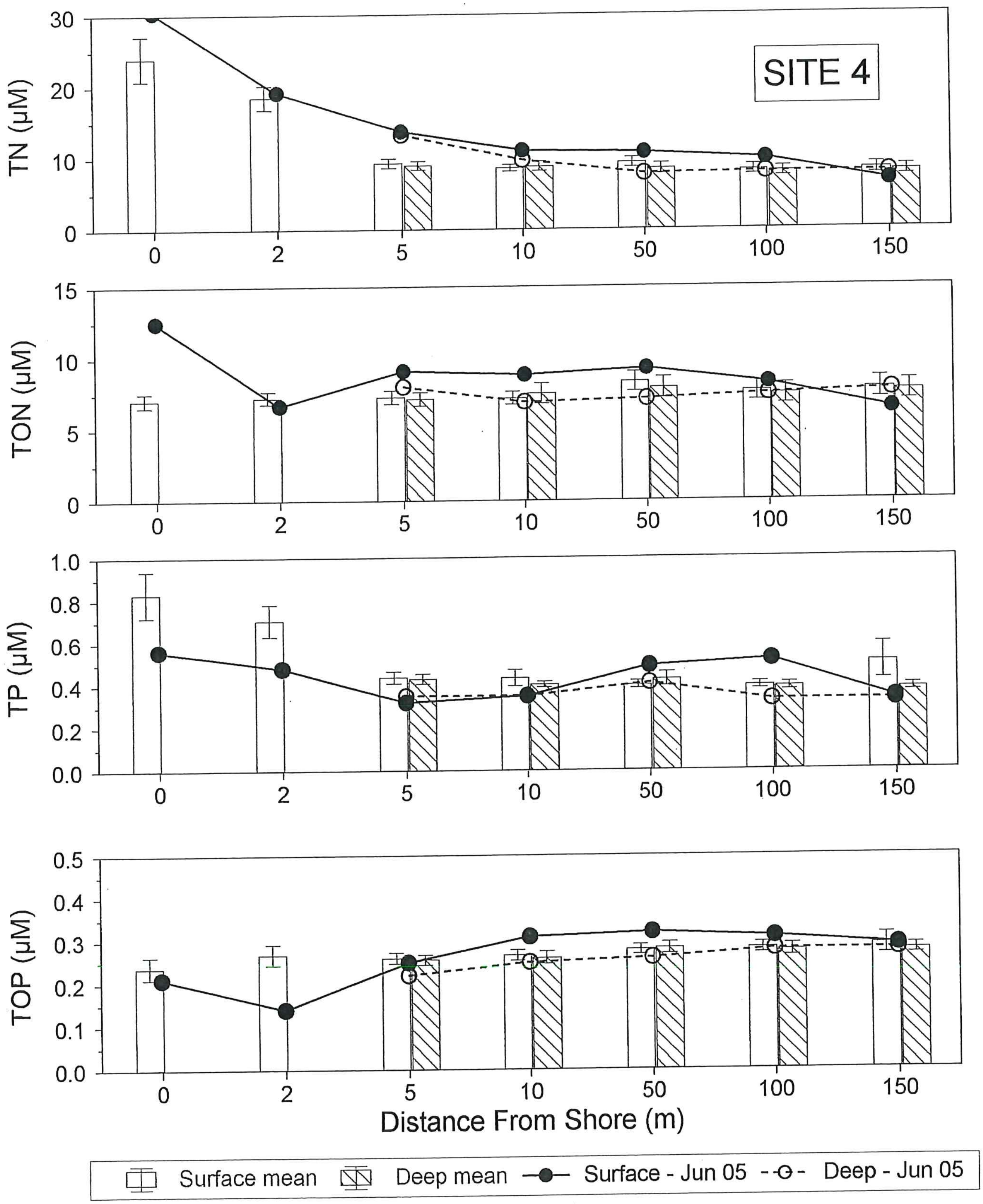

FIGURE 14. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

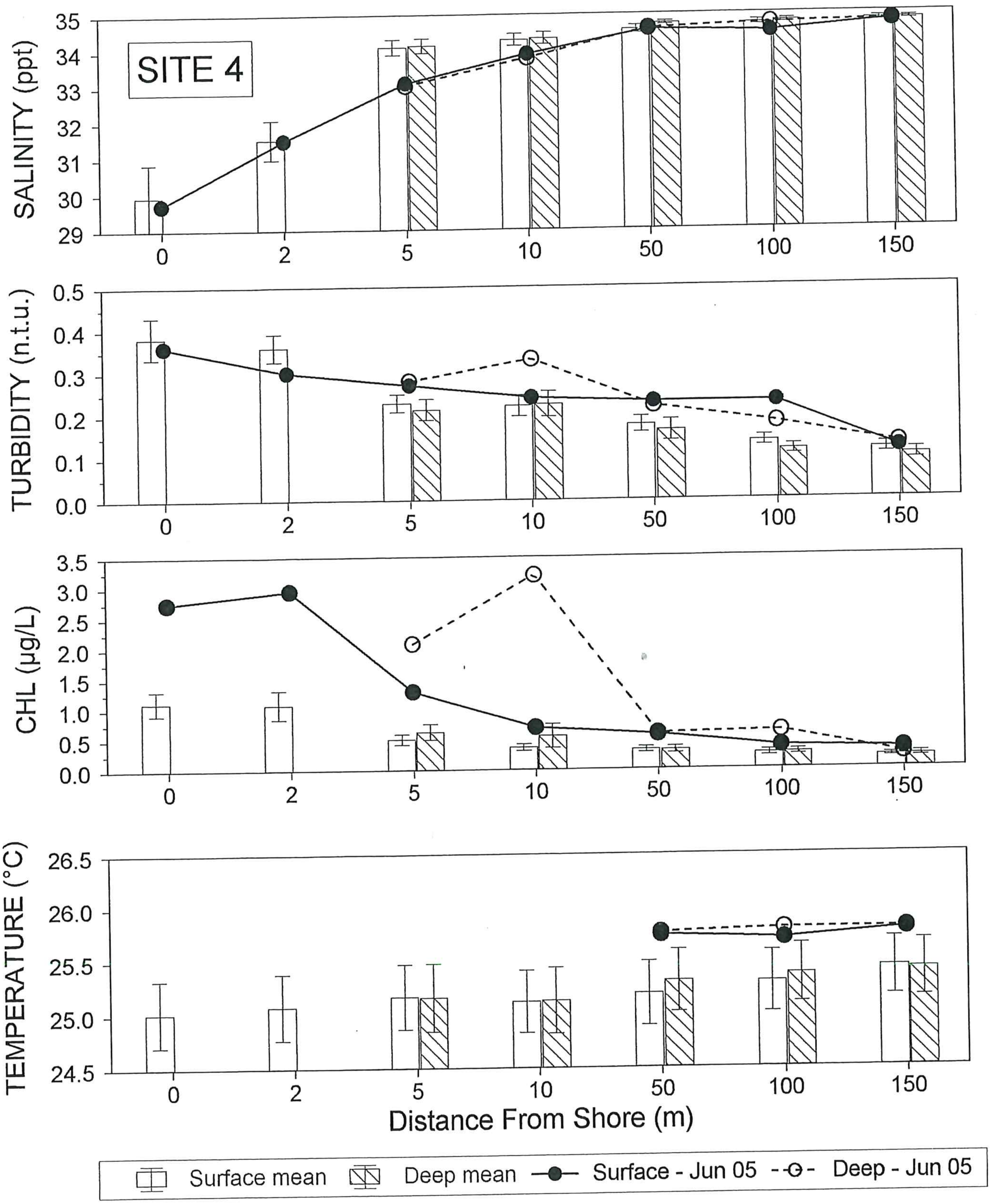

FIGURE 15. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=15). Error bars represent standard error of the mean. For site location, see Figure 1.

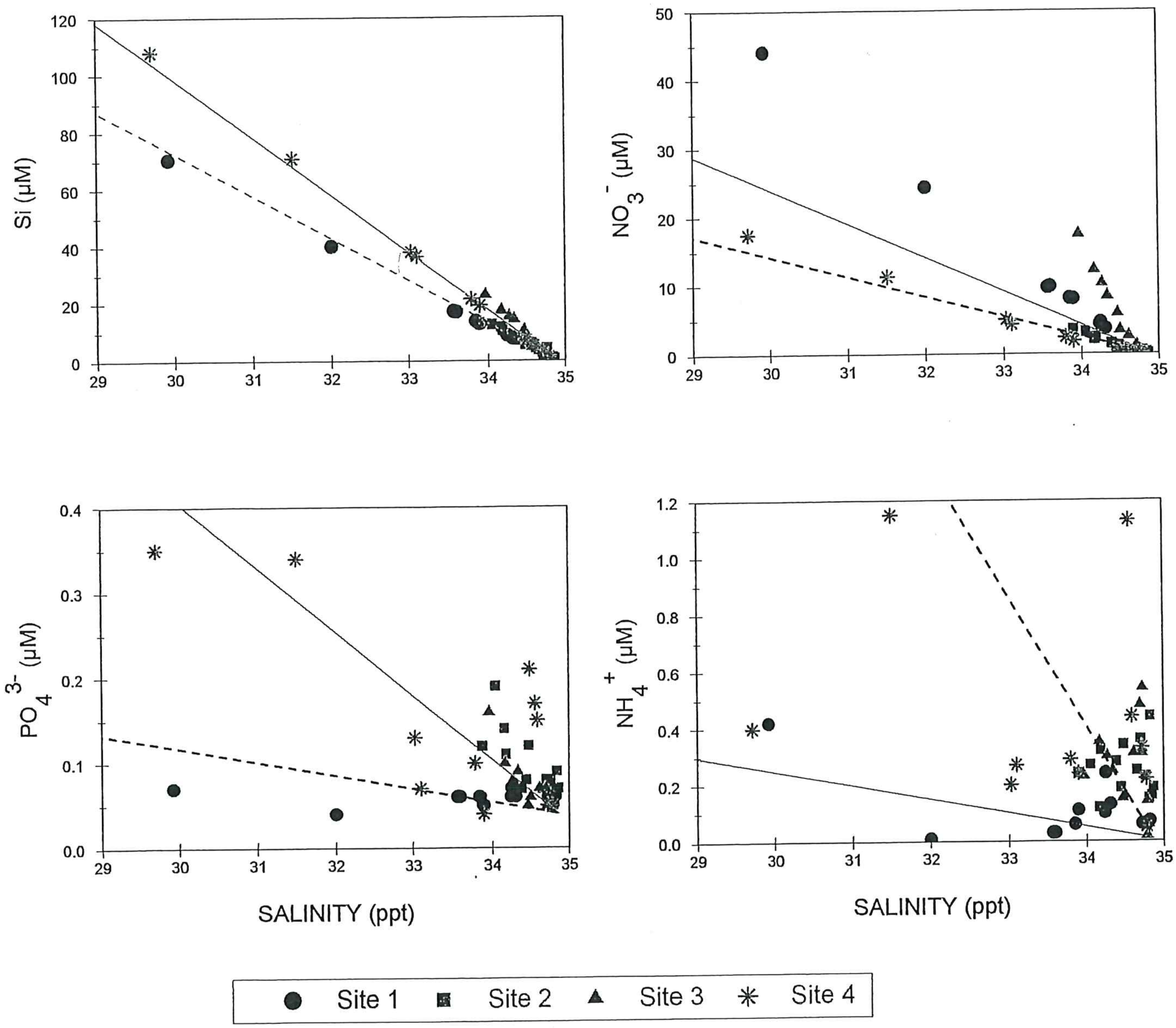

FIGURE 16. Mixing diagram showing concentration of dissolved nutrients from samples collected offshore of the Makena Resort on June 19, 2005 as functions of salinity. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from a golf course irrigation well. Dotted black line is mixing line constructed from open coastal water with water from irrigation lake 10 used to feed both North and South golf courses. For sampling site locations, see Figure 1.

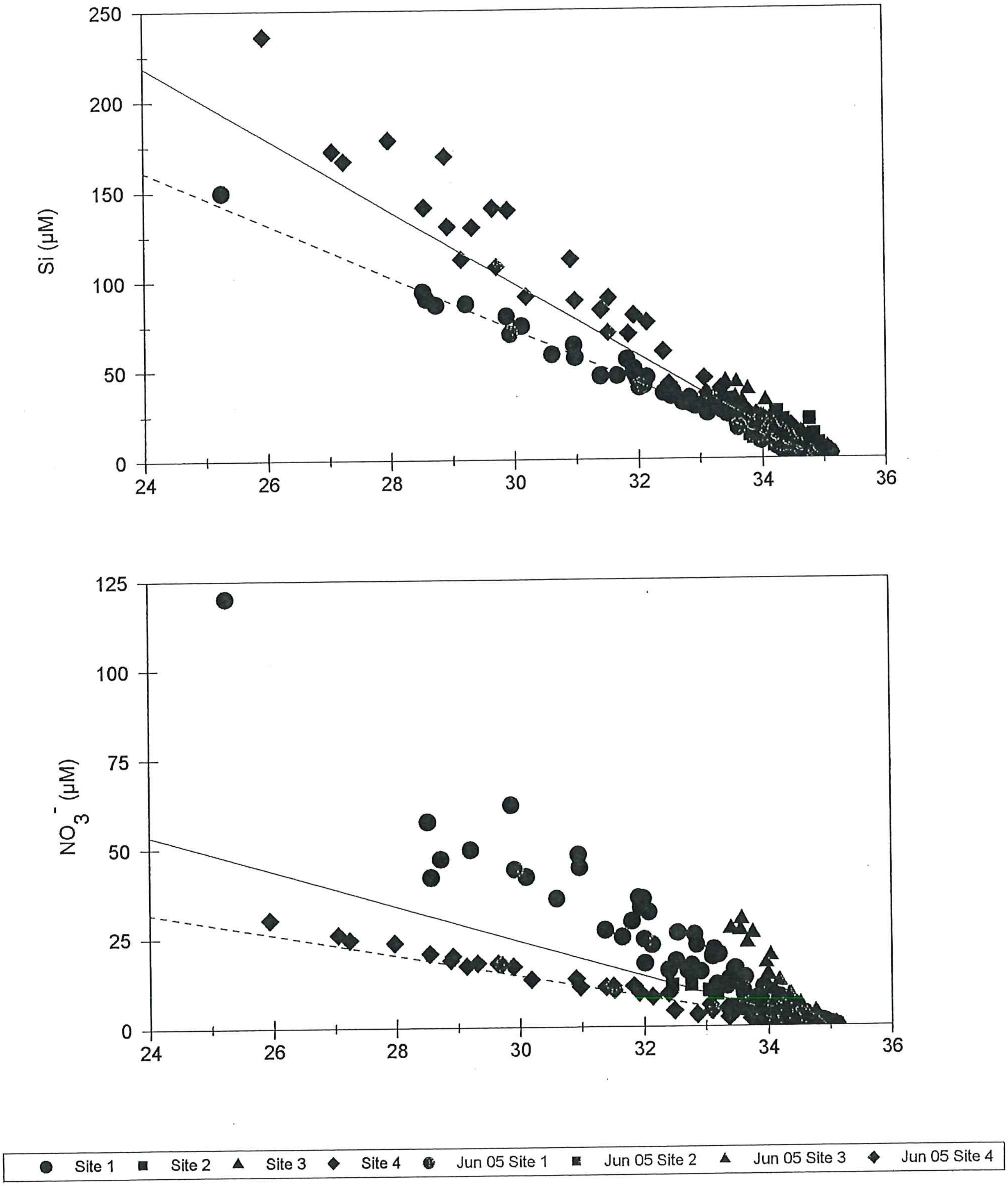

FIGURE 17. Silicate and nitrate, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and June 2005. Red symbols are data from June 2005 survey. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from a golf course irrigation well. Dotted black line is mixing line constructed from open coastal water with water from irrigation lake 10 used to feed both North and South golf courses. For sampling site locations, see Figure 1.

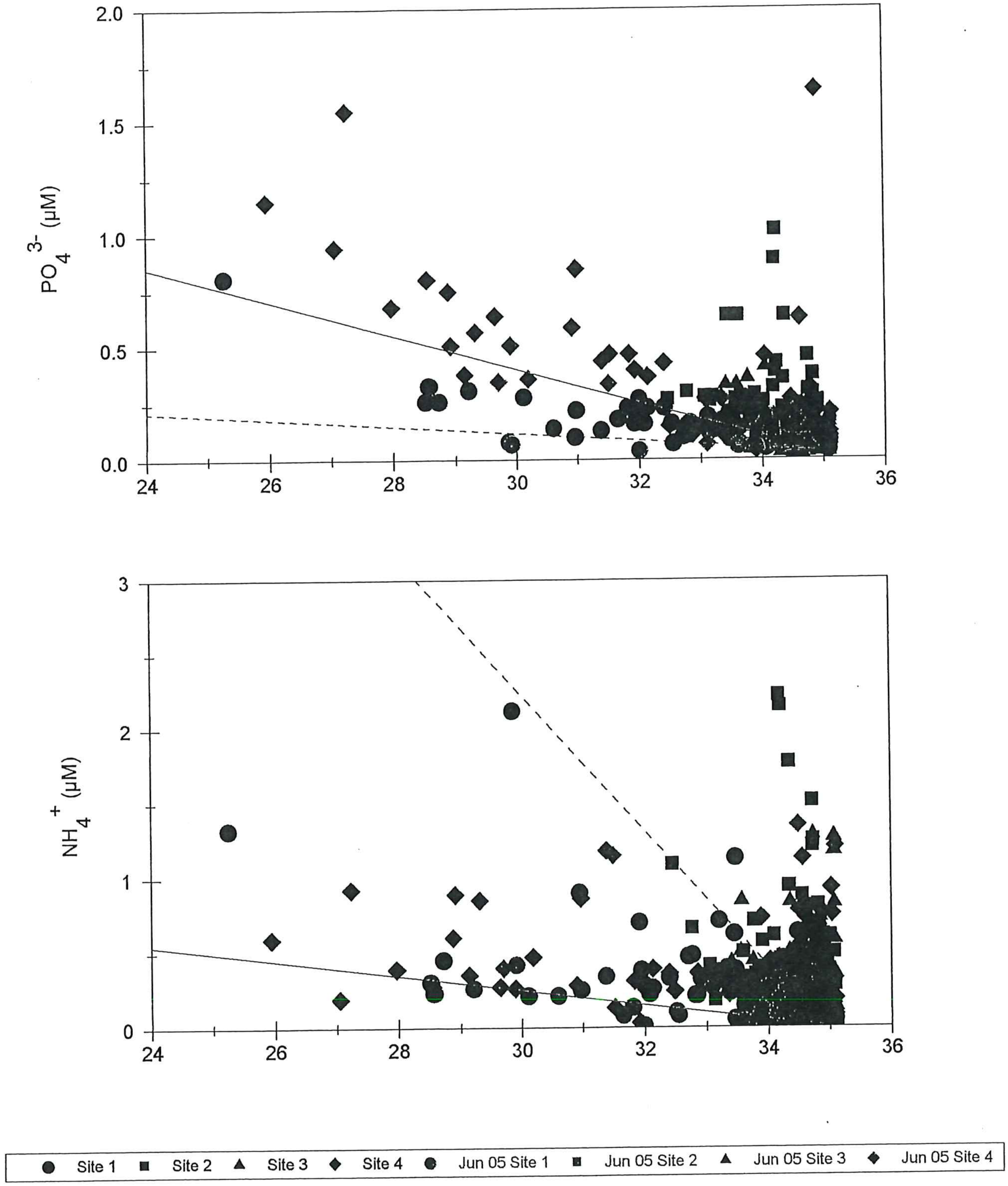

FIGURE 18. Phosphate and ammonium, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and June 2005. Red symbols are data during the June 2005 survey. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from a golf course irrigation well. Dotted black line is mixing line constructed from open coastal water with water from irrigation lake 10 used to feed both North and South golf courses. For sampling site locations, see Figure 1.

TABLE 1. Water chemistry measureme om ocean water samples collected in the vicinity of the kena Resort on June 19, 2005. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep, NA=data not available. Also shown are the State of Hawaii, Department of Health (DOH) "not to exceed more than 10% of the time" and "not to exceed more than 2% of the time" water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH 10% "dry" standards; boxed and shaded values exceed DOH 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (ppt)	CHL a (µg/L)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	0.1	0.07	44.08	0.42	70.42	0.28	10.13	0.35	54.63	0.35	29.921	9.19	NA	8.23	NA
	2 S	0.1	0.04	24.34	0.01	40.18	0.26	8.74	0.30	33.09	0.26	32.003	4.25	NA	8.23	NA
	5 S	0.1	0.06	9.89	0.03	17.17	0.29	9.79	0.35	19.71	0.21	33.599	2.35	NA	8.21	NA
	5 D	2.5	0.06	9.68	0.03	17.38	0.27	9.32	0.33	19.03	0.20	33.569	1.62	NA	8.21	NA
	10 S	0.1	0.06	8.14	0.06	13.91	0.27	9.12	0.33	17.32	0.19	33.850	2.73	NA	8.20	NA
	10 D	3.0	0.07	4.59	0.24	8.89	0.25	8.78	0.32	13.61	0.21	34.252	1.77	NA	8.19	NA
	50 S	0.1	0.06	3.63	0.13	7.90	0.27	8.95	0.33	12.71	0.19	34.313	1.68	25.73	8.20	97.25
	50 D	4.1	0.06	0.49	0.06	2.23	0.26	8.78	0.32	9.33	0.15	34.728	1.07	25.83	8.21	97.43
	100 S	0.1	0.06	4.35	0.10	8.83	0.26	8.29	0.32	12.74	0.20	34.243	1.08	25.76	8.20	98.14
	100 D	6.4	0.05	0.14	0.06	1.32	0.26	8.69	0.31	8.89	0.13	34.790	0.52	25.85	8.22	98.08
	150 S	0.1	0.05	8.07	0.11	13.01	0.26	8.86	0.31	17.04	0.21	33.894	0.76	25.74	8.20	96.46
	150 D	10.5	0.06	0.17	0.07	0.89	0.27	8.35	0.33	8.59	0.10	34.820	0.36	25.79	8.21	96.09
MAKENA 2	0 S	0.1	0.14	2.20	0.12	11.79	0.29	9.06	0.43	11.38	0.84	34.169	0.88	NA	8.20	NA
	2 S	0.1	0.11	2.38	0.32	10.72	0.30	8.64	0.41	11.34	0.58	34.188	0.61	NA	8.20	NA
	5 S	0.1	0.19	3.17	0.27	12.76	0.26	8.12	0.45	11.56	0.90	34.054	0.62	NA	8.19	NA
	5 D	1.5	0.12	1.16	0.34	5.54	0.26	8.50	0.38	10.00	0.33	34.484	0.88	NA	8.20	NA
	10 S	0.1	0.12	3.62	0.24	13.47	0.28	7.48	0.40	11.34	0.42	33.888	0.71	25.68	8.18	97.05
	10 D	2.4	0.08	0.10	0.23	4.40	0.24	7.66	0.32	7.99	0.15	34.767	0.62	25.87	8.21	95.80
	50 S	0.1	0.07	1.46	0.28	7.19	0.34	8.03	0.41	9.77	0.30	34.388	0.57	25.69	8.18	93.67
	50 D	3.8	0.07	0.08	0.15	1.15	0.29	7.65	0.36	7.88	0.14	34.808	0.34	25.87	8.21	96.00
	100 S	0.1	0.08	0.64	0.19	7.28	0.29	8.91	0.37	9.74	0.35	34.452	0.44	25.69	8.18	95.57
	100 D	4.7	0.07	0.08	0.44	1.14	0.28	7.73	0.35	8.25	0.11	34.825	0.46	25.84	8.21	95.79
	150 S	0.1	0.07	0.25	0.25	4.03	0.27	9.24	0.34	9.74	0.24	34.657	0.31	25.79	8.19	95.41
	150 D	9.5	0.09	0.21	0.16	1.14	0.27	7.91	0.36	8.28	0.14	34.846	0.27	25.74	8.21	94.38
	200 S	0.1	0.08	0.36	0.36	3.00	0.25	7.79	0.33	8.51	0.17	34.705	0.27	25.75	8.20	95.65
	200 D	13.4	0.07	0.04	0.19	0.78	0.28	7.87	0.35	8.10	0.11	34.866	0.23	25.74	8.21	95.57
MAKENA 3	0 S	0.1	0.09	8.46	0.25	14.64	0.28	8.86	0.37	17.57	0.86	34.338	0.67	NA	8.15	NA
	2 S	0.1	0.16	17.48	0.23	23.19	0.22	6.08	0.38	23.79	0.49	33.970	1.23	NA	8.14	NA
	5 S	0.1	0.10	12.26	0.35	17.80	0.26	7.16	0.36	19.77	0.34	34.170	0.70	NA	8.13	NA
	5 D	3.0	0.08	10.30	0.30	15.63	0.24	7.36	0.32	17.96	0.29	34.271	0.81	NA	8.13	NA
	10 S	0.1	0.05	5.89	0.15	10.64	0.24	8.28	0.29	14.32	0.24	34.470	0.47	NA	8.13	NA
	10 D	4.5	0.06	3.41	0.16	7.85	0.25	8.05	0.31	11.62	0.20	34.503	0.48	NA	8.13	NA
	50 S	0.1	0.07	2.59	0.31	5.65	0.27	9.84	0.34	12.74	0.21	34.616	0.35	25.81	8.13	90.24
	50 D	3.5	0.05	1.16	0.31	2.91	0.28	9.24	0.33	10.71	0.16	34.720	0.46	25.86	8.16	87.37
	100 S	0.1	0.07	0.94	0.48	3.39	0.26	7.26	0.33	8.68	0.13	34.699	0.29	25.77	8.18	92.23
	100 D	6.2	0.05	0.02	0.14	0.98	0.27	7.13	0.32	7.29	0.09	34.784	0.29	25.83	8.20	93.33
	150 S	0.1	0.06	0.53	0.54	2.37	0.28	6.71	0.34	7.78	0.12	34.732	0.24	25.83	8.20	94.90
	150 D	8.2	0.06	0.09	0.02	1.14	0.28	7.20	0.34	7.31	0.10	34.783	0.28	25.77	8.21	96.23
MAKENA 4	0 S	0.1	0.35	17.52	0.40	108.07	0.21	12.47	0.56	30.39	0.36	29.704	2.74	NA	8.15	NA
	2 S	0.1	0.34	11.36	1.15	70.85	0.14	6.65	0.48	19.16	0.30	31.503	2.95	NA	8.14	NA
	5 S	0.1	0.07	4.34	0.27	36.80	0.25	9.09	0.32	13.70	0.27	33.098	1.29	NA	8.16	NA
	5 D	1.5	0.13	5.05	0.20	38.26	0.22	8.00	0.35	13.25	0.28	33.025	2.08	NA	8.16	NA
	10 S	0.1	0.04	1.92	0.24	19.60	0.31	8.82	0.35	10.98	0.24	33.896	0.69	NA	8.16	NA
	10 D	2.5	0.10	2.44	0.29	21.77	0.25	6.92	0.35	9.65	0.33	33.789	3.20	NA	8.16	NA
	50 S	0.1	0.17	0.33	1.13	5.53	0.32	9.25	0.49	10.71	0.23	34.561	0.57	25.74	8.15	94.19
	50 D	5.9	0.15	0.18	0.44	5.40	0.26	7.12	0.41	7.74	0.22	34.591	0.59	25.76	8.15	92.88
	100 S	0.1	0.21	0.25	1.35	7.38	0.31	8.25	0.52	9.85	0.23	34.494	0.37	25.70	8.14	92.93
	100 D	6.0	0.05	0.12	0.33	2.32	0.28	7.47	0.33	7.92	0.18	34.720	0.62	25.80	8.17	88.63
	150 S	0.1	0.05	0.11	0.22	1.24	0.29	6.44	0.34	6.77	0.12	34.772	0.33	25.79	8.19	92.50
	150 D	7.4	0.05	0.08	0.05	1.59	0.28	7.75	0.33	7.88	0.13	34.778	0.24	25.80	8.19	90.60
DOH WQS	DRY	10%		0.71	0.36				0.96	12.86	0.50	*	0.50	**	***	
		2%		1.43	0.64				1.45	17.86	1.00		1.00			
	WET	10%		1.00	0.61				1.29	17.85	1.25	*	0.90	**	***	
		2%		1.78	1.07				1.93	25.00	2.00		1.75			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

TABLE 2. Water chemistry measurements from o[illegible] water samples (in μg/L) collected in the vicinity of the Make[illegible] [illegible]sort on June 19, 2005. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep, NA=data not available. Also shown are the State of Hawaii, Department of Health (DOH) "not to exceed more than 10% of the time" and "not to exceed more than 2% of the time" water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH 10% "dry" standards; boxed and shaded values exceed DOH 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO4 (μg/L)	NO3 (μg/L)	NH4 (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	0.1	2.17	617.12	5.88	1,978.80	8.68	141.82	10.85	764.82	0.35	29.921	9.19	NA	8.23	NA
	2 S	0.1	1.24	340.76	0.14	1,129.06	8.06	122.36	9.30	463.26	0.26	32.003	4.25	NA	8.23	NA
	5 S	0.1	1.86	138.46	0.42	482.48	8.99	137.06	10.85	275.94	0.21	33.599	2.35	NA	8.21	NA
	5 D	2.5	1.86	135.52	0.42	488.38	8.37	130.48	10.23	266.42	0.20	33.569	1.62	NA	8.21	NA
	10 S	0.1	1.86	113.96	0.84	390.87	8.37	127.68	10.23	242.48	0.19	33.850	2.73	NA	8.20	NA
	10 D	3.0	2.17	64.26	3.36	249.81	7.75	122.92	9.92	190.54	0.21	34.252	1.77	NA	8.19	NA
	50 S	0.1	1.86	50.82	1.82	221.99	8.37	125.30	10.23	177.94	0.19	34.313	1.68	25.73	8.20	97.25
	50 D	4.1	1.86	6.86	0.84	62.66	8.06	122.92	9.92	130.62	0.15	34.728	1.07	25.83	8.21	97.43
	100 S	0.1	1.86	60.90	1.40	248.12	8.06	116.06	9.92	178.36	0.20	34.243	1.08	25.76	8.20	98.14
	100 D	6.4	1.55	1.96	0.84	37.09	8.06	121.66	9.61	124.46	0.13	34.790	0.52	25.85	8.22	98.08
	150 S	0.1	1.55	112.98	1.54	365.58	8.06	124.04	9.61	238.56	0.21	33.894	0.76	25.74	8.20	96.46
	150 D	10.5	1.86	2.38	0.98	25.01	8.37	116.90	10.23	120.26	0.10	34.820	0.36	25.79	8.21	96.09
MAKENA 2	0 S	0.1	4.34	30.80	1.68	331.30	8.99	126.84	13.33	159.32	0.84	34.169	0.88	NA	8.20	NA
	2 S	0.1	3.41	33.32	4.48	301.23	9.30	120.96	12.71	158.76	0.58	34.188	0.61	NA	8.20	NA
	5 S	0.1	5.89	44.38	3.78	358.56	8.06	113.68	13.95	161.84	0.90	34.054	0.62	NA	8.19	NA
	5 D	1.5	3.72	16.24	4.76	155.67	8.06	119.00	11.78	140.00	0.33	34.484	0.88	NA	8.20	NA
	10 S	0.1	3.72	50.68	3.36	378.51	8.68	104.72	12.40	158.76	0.42	33.888	0.71	25.68	8.18	97.05
	10 D	2.4	2.48	1.40	3.22	123.64	7.44	107.24	9.92	111.86	0.15	34.767	0.62	25.87	8.21	95.80
	50 S	0.1	2.17	20.44	3.92	202.04	10.54	112.42	12.71	136.78	0.30	34.388	0.57	25.69	8.18	93.67
	50 D	3.8	2.17	1.12	2.10	32.32	8.99	107.10	11.16	110.32	0.14	34.808	0.34	25.87	8.21	96.00
	100 S	0.1	2.48	8.96	2.66	204.57	8.99	124.74	11.47	136.36	0.35	34.452	0.44	25.69	8.18	95.57
	100 D	4.7	2.17	1.12	6.16	32.03	8.68	108.22	10.85	115.50	0.11	34.825	0.46	25.84	8.21	95.79
	150 S	0.1	2.17	3.50	3.50	113.24	8.37	129.36	10.54	136.36	0.24	34.657	0.31	25.79	8.19	95.41
	150 D	9.5	2.79	2.94	2.24	32.03	8.37	110.74	11.16	115.92	0.14	34.846	0.27	25.74	8.21	94.38
	200 S	0.1	2.48	5.04	5.00	84.30	7.75	109.06	10.23	119.14	0.17	34.705	0.27	25.75	8.20	95.65
	200 D	13.4	2.17	0.56	2.66	21.92	8.68	110.18	10.85	113.40	0.11	34.866	0.23	25.74	8.21	95.57
MAKENA 3	0 S	0.1	2.79	118.44	3.50	411.38	8.68	124.04	11.47	245.98	0.86	34.338	0.67	NA	8.15	NA
	2 S	0.1	4.96	244.72	3.22	651.64	6.82	85.12	11.78	333.06	0.49	33.970	1.23	NA	8.14	NA
	5 S	0.1	3.10	171.64	4.90	500.18	8.06	100.24	11.16	276.78	0.34	34.170	0.70	NA	8.13	NA
	5 D	3.0	2.48	144.20	4.20	439.20	7.44	103.04	9.92	251.44	0.29	34.271	0.81	NA	8.13	NA
	10 S	0.1	1.55	82.46	2.10	298.98	7.44	115.92	8.99	200.48	0.24	34.470	0.47	NA	8.13	NA
	10 D	4.5	1.86	47.76	2.24	220.51	7.74	112.75	9.60	162.75	0.20	34.503	0.48	NA	8.13	NA
	50 S	0.1	2.17	36.26	4.34	158.77	8.37	137.76	10.54	178.36	0.21	34.616	0.35	25.81	8.13	90.24
	50 D	3.5	1.55	16.24	4.34	81.77	8.68	129.36	10.23	149.94	0.16	34.720	0.46	25.86	8.16	87.37
	100 S	0.1	2.17	13.16	6.72	95.26	8.06	101.64	10.23	121.52	0.13	34.699	0.29	25.77	8.18	92.23
	100 D	6.2	1.55	0.28	1.96	27.54	8.37	99.82	9.92	102.06	0.09	34.784	0.29	25.83	8.20	93.33
	150 S	0.1	1.86	7.42	7.56	66.60	8.68	93.94	10.54	108.92	0.12	34.732	0.24	25.83	8.20	94.90
	150 D	8.2	1.86	1.26	0.28	32.03	8.68	100.80	10.54	102.34	0.10	34.783	0.28	25.77	8.21	96.23
MAKENA 4	0 S	0.1	10.85	245.28	5.60	3,036.77	6.51	174.58	17.36	425.46	0.36	29.704	2.74	NA	8.15	NA
	2 S	0.1	10.54	159.04	16.11	1,990.89	4.34	93.10	14.88	268.24	0.30	31.503	2.95	NA	8.14	NA
	5 S	0.1	2.17	60.76	3.78	1,034.08	7.75	127.26	9.92	191.80	0.27	33.098	1.29	NA	8.16	NA
	5 D	1.5	4.03	70.70	2.80	1,075.11	6.82	112.00	10.85	185.50	0.28	33.025	2.08	NA	8.16	NA
	10 S	0.1	1.24	26.88	3.36	550.76	9.61	123.48	10.85	153.72	0.24	33.896	0.69	NA	8.16	NA
	10 D	2.5	3.10	34.16	4.06	611.74	7.75	96.88	10.85	135.10	0.33	33.789	3.20	NA	8.16	NA
	50 S	0.1	5.27	4.62	15.83	155.39	9.92	129.50	15.19	149.94	0.23	34.561	0.57	25.74	8.15	94.19
	50 D	5.9	4.65	2.52	6.16	151.74	8.06	99.68	12.71	108.36	0.22	34.591	0.59	25.76	8.15	92.88
	100 S	0.1	6.51	3.50	18.91	207.38	9.61	115.50	16.12	137.90	0.23	34.494	0.37	25.70	8.14	92.93
	100 D	6.0	1.55	1.68	4.62	65.19	8.68	104.58	10.23	110.88	0.18	34.720	0.62	25.80	8.17	88.63
	150 S	0.1	1.55	1.54	3.08	34.84	8.99	90.16	10.54	94.78	0.12	34.772	0.33	25.79	8.19	92.50
	150 D	7.4	1.55	1.12	0.70	44.68	8.68	108.50	10.23	110.32	0.13	34.778	0.24	25.80	8.19	90.60
DOH WQS		DRY	10%	10.00	5.00				30.00	180.00	0.50	*	0.50	**	***	
			2%	20.00	9.00				45.00	250.00	1.00		1.00			
		WET	10%	14.00	8.50				40.00	250.00	1.25	*	0.90	**	***	
			2%	25.00	15.00				60.00	350.00	2.00		1.75			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

TABLE 3. Geometric mean data from water chemistry measurements (in μM) off the Makena Resort collected since August 1995 (N=15). For geometric mean calculations, detection limits were used in cases where sample was below detection limit. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. Also shown are State of Hawaii, Department of Health (DOH) geometric mean water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH GM 10% "dry" standards; boxed and shaded values exceed DOH GM 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO4 (μM)	NO3 (μM)	NH4 (μM)	Si (μM)	TOP (μM)	TON (μM)	TP (μM)	TN (μM)	TURB (NTU)	SALINITY (ppt)	CHL a ($\mu g/L$)	TEMP (deg.C)	pH
MAKENA 1	0 S	0.1	0.19	33.55	0.33	56.48	0.22	8.11	0.47	44.40	0.33	30.609	1.03	25.41	8.16
	2 S	0.1	0.14	22.41	0.20	38.84	0.24	7.81	0.40	31.45	0.27	32.235	0.93	25.44	8.18
	5 S	0.1	0.12	10.38	0.16	20.82	0.25	7.85	0.39	20.90	0.23	33.238	0.71	25.49	8.18
	5 D	2.5	0.12	9.07	0.24	18.95	0.27	7.57	0.40	19.37	0.21	33.385	0.80	25.51	8.17
	10 S	0.1	0.10	3.92	0.16	9.95	0.25	7.08	0.36	12.36	0.19	34.180	0.46	25.51	8.17
	10 D	3.0	0.10	2.91	0.21	7.85	0.28	7.34	0.40	11.03	0.19	34.361	0.49	25.51	8.17
	50 S	0.1	0.10	2.76	0.19	7.34	0.26	7.02	0.37	11.04	0.17	34.367	0.36	25.62	8.15
	50 D	4.1	0.09	0.39	0.12	2.73	0.27	7.35	0.37	8.03	0.12	34.759	0.32	25.63	8.15
	100 S	0.1	0.09	0.99	0.12	4.81	0.26	6.52	0.37	9.58	0.13	34.512	0.32	25.59	8.15
	100 D	6.4	0.08	0.10	0.07	1.95	0.27	7.10	0.36	7.38	0.09	34.796	0.27	25.61	8.17
	150 S	0.1	0.09	0.36	0.11	3.35	0.25	6.87	0.35	8.40	0.12	34.655	0.23	25.72	8.15
	150 D	10.5	0.08	0.08	0.08	1.71	0.26	6.80	0.35	7.06	0.10	34.804	0.20	25.64	8.17
MAKENA 2	0 S	0.1	0.22	3.80	0.30	20.65	0.32	7.98	0.58	12.75	1.02	33.851	0.92	25.55	8.15
	2 S	0.1	0.22	3.76	0.29	18.75	0.33	7.91	0.59	12.60	0.83	33.840	0.97	25.54	8.15
	5 S	0.1	0.20	3.44	0.28	15.49	0.28	6.85	0.50	11.31	0.52	34.012	0.68	25.51	8.16
	5 D	1.5	0.20	3.12	0.37	14.95	0.32	7.17	0.54	11.81	0.50	34.051	0.88	25.53	8.15
	10 S	0.1	0.15	1.95	0.20	10.18	0.31	4.68	0.48	9.23	0.37	34.316	0.49	25.45	8.16
	10 D	2.4	0.14	1.22	0.25	8.25	0.32	7.14	0.49	9.35	0.30	34.461	0.59	25.53	8.16
	50 S	0.1	0.12	1.23	0.28	7.58	0.33	7.32	0.48	9.35	0.31	34.441	0.42	25.51	8.14
	50 D	3.8	0.10	0.27	0.19	3.13	0.32	7.57	0.45	8.24	0.20	34.755	0.52	25.57	8.16
	100 S	0.1	0.10	0.52	0.19	4.22	0.29	7.39	0.40	8.48	0.18	34.622	0.33	25.62	8.15
	100 D	4.7	0.08	0.19	0.19	2.44	0.29	6.98	0.39	7.49	0.13	34.775	0.34	25.60	8.16
	150 S	0.1	0.09	0.27	0.23	3.13	0.28	7.43	0.40	8.05	0.14	34.729	0.28	25.63	8.16
	150 D	9.5	0.08	0.13	0.16	2.18	0.30	7.68	0.40	8.10	0.12	34.793	0.28	25.61	8.17
	200 S	0.1	0.08	0.22	0.19	2.52	0.28	7.21	0.37	7.93	0.12	34.789	0.26	25.72	8.17
	200 D	13.4	0.08	0.06	0.20	1.72	0.29	7.69	0.38	8.06	0.10	34.834	0.30	25.68	8.18
MAKENA 3	0 S	0.1	0.10	0.84	0.30	4.91	0.28	7.16	0.41	10.32	0.31	34.595	0.44	25.34	8.18
	2 S	0.1	0.14	1.42	0.31	6.60	0.28	6.99	0.44	12.59	0.30	34.435	0.44	25.41	8.16
	5 S	0.1	0.12	1.03	0.27	5.66	0.27	7.13	0.41	11.45	0.22	34.537	0.32	25.45	8.16
	5 D	3.0	0.12	0.87	0.29	5.28	0.28	6.89	0.41	10.78	0.23	34.571	0.39	25.45	8.16
	10 S	0.1	0.10	0.55	0.29	3.72	0.28	7.29	0.40	9.73	0.17	34.685	0.25	25.36	8.16
	10 D	4.5	0.09	0.42	0.24	3.36	0.28	7.08	0.39	8.83	0.17	34.719	0.30	25.41	8.16
	50 S	0.1	0.09	0.30	0.25	2.94	0.27	6.99	0.37	8.26	0.14	34.749	0.22	25.50	8.14
	50 D	3.5	0.08	0.19	0.24	2.48	0.28	7.16	0.37	7.83	0.13	34.799	0.21	25.50	8.16
	100 S	0.1	0.07	0.13	0.22	2.25	0.28	7.15	0.37	7.74	0.12	34.791	0.16	25.52	8.15
	100 D	6.2	0.07	0.07	0.20	1.90	0.27	6.65	0.36	7.05	0.10	34.815	0.19	25.45	8.16
	150 S	0.1	0.06	0.08	0.20	2.00	0.27	6.56	0.34	7.07	0.10	34.797	0.17	25.54	8.17
	150 D	8.2	0.08	0.05	0.14	1.83	0.28	6.67	0.37	6.99	0.09	34.806	0.21	25.50	8.18
MAKENA 4	0 S	0.1	0.43	9.19	0.37	74.66	0.21	6.88	0.73	20.68	0.34	29.727	0.85	24.98	8.04
	2 S	0.1	0.35	6.74	0.37	56.52	0.25	7.07	0.65	17.18	0.33	31.470	0.78	25.04	8.04
	5 S	0.1	0.15	1.07	0.20	13.43	0.25	7.05	0.42	9.00	0.21	34.111	0.41	25.14	8.07
	5 D	1.5	0.15	0.91	0.25	12.27	0.25	6.91	0.42	8.74	0.20	34.151	0.48	25.13	8.08
	10 S	0.1	0.13	0.77	0.25	10.34	0.26	6.96	0.42	8.35	0.20	34.306	0.30	25.09	8.09
	10 D	2.5	0.13	0.55	0.28	9.41	0.25	7.14	0.40	8.51	0.20	34.340	0.35	25.10	8.09
	50 S	0.1	0.11	0.42	0.27	5.96	0.27	8.00	0.39	9.00	0.16	34.569	0.27	25.16	8.09
	50 D	5.9	0.12	0.22	0.21	4.14	0.27	7.45	0.41	8.02	0.14	34.738	0.26	25.28	8.11
	100 S	0.1	0.10	0.23	0.19	4.29	0.27	7.30	0.39	7.88	0.12	34.731	0.20	25.27	8.12
	100 D	6.0	0.10	0.19	0.20	2.99	0.27	7.01	0.38	7.62	0.10	34.779	0.21	25.35	8.13
	150 S	0.1	0.11	0.12	0.14	2.39	0.24	7.44	0.45	7.92	0.10	34.804	0.17	25.41	8.15
	150 D	7.4	0.09	0.12	0.13	2.05	0.27	7.35	0.37	7.73	0.08	34.817	0.17	25.40	8.16
DOH WQS GEOMETRIC MEAN		DRY		0.25	0.14				0.52	7.86	0.20	*	0.15	**	***
		WET		0.36	0.25				0.64	10.71	0.50		0.30		

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

TABLE 4. Geometric mean data (in μg/L) from water chemistry measurements (in μM) off the Makena Resort collected since August 1995 (N=15). For geometric mean calculations, detection limits were used in cases where sample was below detection limit. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. Also shown are State of Hawaii, Department of Health (DOH) geometric mean water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH GM 10% "dry" standards; boxed and shaded values exceed DOH GM 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO4 (μg/L)	NO3 (μg/L)	NH4 (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH
MAKENA 1	0 S	0.1	5.80	469.90	4.60	1,586.52	6.80	113.50	14.50	621.80	0.33	30.609	1.03	25.41	8.16
	2 S	0.1	4.30	313.80	2.80	1,091.02	7.40	109.30	12.30	440.40	0.27	32.235	0.93	25.44	8.18
	5 S	0.1	3.70	145.30	2.20	584.83	7.70	109.90	12.00	292.70	0.23	33.238	0.71	25.49	8.18
	5 D	2.5	3.70	127.00	3.30	532.31	8.30	106.00	12.30	271.20	0.21	33.385	0.80	25.51	8.17
	10 S	0.1	3.00	54.90	2.20	279.50	7.70	99.10	11.10	173.10	0.19	34.180	0.46	25.51	8.17
	10 D	3.0	3.00	40.70	2.90	220.51	8.60	102.80	12.30	154.40	0.19	34.361	0.49	25.51	8.17
	50 S	0.1	3.00	38.60	2.60	206.18	8.00	98.30	11.40	154.60	0.17	34.367	0.36	25.62	8.15
	50 D	4.1	2.70	5.40	1.60	76.69	8.30	102.90	11.40	112.40	0.12	34.759	0.32	25.63	8.15
	100 S	0.1	2.70	13.80	1.60	135.11	8.00	91.30	11.40	134.10	0.13	34.512	0.32	25.59	8.15
	100 D	6.4	2.40	1.40	0.90	54.78	8.30	99.40	11.10	103.30	0.09	34.796	0.27	25.61	8.17
	150 S	0.1	2.70	5.00	1.50	94.10	7.70	96.20	10.80	117.60	0.12	34.655	0.23	25.72	8.15
	150 D	10.5	2.40	1.10	1.10	48.03	8.00	95.20	10.80	98.80	0.10	34.804	0.20	25.64	8.17
MAKENA 2	0 S	0.1	6.80	53.20	4.20	580.06	9.90	111.70	17.90	178.50	1.02	33.851	0.92	25.55	8.15
	2 S	0.1	6.80	52.60	4.00	526.69	10.20	110.70	18.20	176.40	0.83	33.840	0.97	25.54	8.15
	5 S	0.1	6.10	48.10	3.90	435.11	8.60	95.90	15.40	158.40	0.52	34.012	0.68	25.51	8.16
	5 D	1.5	6.10	43.60	5.10	419.95	9.90	100.40	16.70	165.40	0.50	34.051	0.88	25.53	8.15
	10 S	0.1	4.60	27.30	2.80	285.96	9.60	65.50	14.80	129.20	0.37	34.316	0.49	25.45	8.16
	10 D	2.4	4.30	17.00	3.50	231.74	9.90	100.00	15.10	130.90	0.30	34.461	0.59	25.53	8.16
	50 S	0.1	3.70	17.20	3.90	212.92	10.20	102.50	14.80	130.90	0.31	34.441	0.42	25.51	8.14
	50 D	3.8	3.00	3.70	2.60	87.92	9.90	106.00	13.90	115.40	0.20	34.755	0.52	25.57	8.16
	100 S	0.1	3.00	7.20	2.60	118.54	8.90	103.50	12.30	118.70	0.18	34.622	0.33	25.62	8.15
	100 D	4.7	2.40	2.60	2.60	68.54	8.90	97.70	12.00	104.90	0.13	34.775	0.34	25.60	8.16
	150 S	0.1	2.70	3.70	3.20	87.92	8.60	104.00	12.30	112.70	0.14	34.729	0.28	25.63	8.16
	150 D	9.5	2.40	1.80	2.20	61.24	9.20	107.50	12.30	113.40	0.12	34.793	0.28	25.61	8.17
	200 S	0.1	2.40	3.00	2.60	70.79	8.60	100.90	11.40	111.00	0.12	34.789	0.26	25.72	8.17
	200 D	13.4	2.40	0.80	2.80	48.31	8.90	107.70	11.70	112.80	0.10	34.834	0.30	25.68	8.18
MAKENA 3	0 S	0.1	3.00	11.70	4.20	137.92	8.60	100.20	12.60	144.50	0.31	34.595	0.44	25.34	8.18
	2 S	0.1	4.30	19.80	4.30	185.39	8.60	97.90	13.60	176.30	0.30	34.435	0.44	25.41	8.16
	5 S	0.1	3.70	14.40	3.70	158.99	8.30	99.80	12.60	160.30	0.22	34.537	0.32	25.45	8.16
	5 D	3.0	3.70	12.10	4.00	148.32	8.60	96.50	12.60	150.90	0.23	34.571	0.39	25.45	8.16
	10 S	0.1	3.00	7.70	4.00	104.49	8.60	102.10	12.30	136.20	0.17	34.685	0.25	25.36	8.16
	10 D	4.5	2.70	5.80	3.30	94.38	8.60	99.10	12.00	123.60	0.17	34.719	0.30	25.41	8.16
	50 S	0.1	2.70	4.20	3.50	82.58	8.30	97.90	11.40	115.60	0.14	34.749	0.22	25.50	8.14
	50 D	3.5	2.40	2.60	3.30	69.66	8.60	100.20	11.40	109.60	0.13	34.799	0.21	25.50	8.16
	100 S	0.1	2.10	1.80	3.00	63.20	8.60	100.10	11.40	108.40	0.12	34.791	0.16	25.52	8.15
	100 D	6.2	2.10	0.90	2.80	53.37	8.30	93.10	11.10	98.70	0.10	34.815	0.19	25.45	8.16
	150 S	0.1	1.80	1.10	2.80	56.18	8.30	91.80	10.50	99.00	0.10	34.797	0.17	25.54	8.17
	150 D	8.2	2.40	0.70	1.90	51.40	8.60	93.40	11.40	97.90	0.09	34.806	0.21	25.50	8.18
MAKENA 4	0 S	0.1	13.30	128.70	5.10	2,097.20	6.50	96.30	22.60	289.60	0.34	29.727	0.85	24.98	8.04
	2 S	0.1	10.80	94.40	5.10	1,587.65	7.70	99.00	20.10	240.60	0.33	31.470	0.78	25.04	8.04
	5 S	0.1	4.60	14.90	2.80	377.25	7.70	98.70	13.00	126.00	0.21	34.111	0.41	25.14	8.07
	5 D	1.5	4.60	12.70	3.50	344.66	7.70	96.70	13.00	122.40	0.20	34.151	0.48	25.13	8.08
	10 S	0.1	4.00	10.70	3.50	290.45	8.00	97.40	13.00	116.90	0.20	34.306	0.30	25.09	8.09
	10 D	2.5	4.00	7.70	3.90	264.33	7.70	100.00	12.30	119.10	0.20	34.340	0.35	25.10	8.09
	50 S	0.1	3.40	5.80	3.70	167.42	8.30	112.00	12.00	126.00	0.16	34.569	0.27	25.16	8.09
	50 D	5.9	3.70	3.00	2.90	116.29	8.30	104.30	12.60	112.30	0.14	34.738	0.26	25.28	8.11
	100 S	0.1	3.00	3.20	2.60	120.51	8.30	102.20	12.00	110.30	0.12	34.731	0.20	25.27	8.12
	100 D	6.0	3.00	2.60	2.80	83.99	8.30	98.10	11.70	106.70	0.10	34.779	0.21	25.35	8.13
	150 S	0.1	3.40	1.60	1.90	67.14	7.40	104.20	13.90	110.90	0.10	34.804	0.17	25.41	8.15
	150 D	7.4	2.70	1.60	1.80	57.58	8.30	102.90	11.40	108.20	0.08	34.817	0.17	25.40	8.16
DOH WQS GEOMETRIC MEAN	DRY			3.50	2.00				16.00	110.00	0.20	*	0.15	**	***
	WET			5.00	3.50				20.00	150.00	0.50		0.30		

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

TABLE 5. Water chemistry measurements in µM and µg/L (shaded) from irrigation wells and two irrigation lakes collected in the vicinity of the Makena Resort on June 29, 2005. For sampling site locations, see Figure 1.

WELLS	PO4 (µM)	PO4 (µg/L)	NO3 (µM)	NO3 (µg/L)	NH4 (µM)	NH4 (µg/L)	Si (µM)	Si (µg/L)	TOP (µM)	TOP (µg/L)	TON (µM)	TON (µg/L)	TP (µM)	TP (µg/L)	TN (µM)	TN (µg/L)	SALINITY (ppt)
1	1.12	34.72	132.48	1,854.7	2.40	33.60	524.0	14723	0.60	18.60	6.72	94.1	1.72	53.32	141.60	1,982	1.288
2	2.52	78.12	164.04	2,296.6	1.20	16.80	734.7	20646	0.68	21.08	2.40	33.6	3.20	99.20	167.64	2,347	1.730
3	2.36	73.16	155.72	2,180.1	2.28	31.92	731.0	20540	0.44	13.64	1.52	21.3	2.80	86.80	159.52	2,233	1.920
4	2.52	78.12	162.80	2,279.2	1.64	22.96	664.9	18683	0.48	14.88	2.00	28.0	3.00	93.00	166.44	2,330	1.79[illegible]
5	2.12	65.72	135.04	1,890.6	1.48	20.72	594.2	16698	0.44	13.64	4.84	67.8	2.56	79.36	141.36	1,979	1.[illegible]
6	1.76	54.56	180.76	2,530.6	1.52	21.28	561.1	15767	0.48	14.88	4.96	69.4	2.24	69.44	187.24	2,621	1.530
10	2.44	75.64	194.84	2,727.8	1.16	16.24	653.4	18359	0.48	14.88	0.60	8.4	2.92	90.52	196.60	2,752	1.976
IL10	0.56	17.36	95.80	1,341.20	15.00	210.00	484.64	13,618.38	1.16	35.96	30.44	426.16	1.72	53.32	141.24	1,977.36	2.05
IL-B	49.86	1,545.66	100.60	1,408.40	46.88	656.32	582.20	16,359.82	1.58	48.98	35.48	496.72	51.44	1,594.64	182.96	2,561.44	2.07