INTRODUCTION

The data in this report were collected during Cruises 9003* and 9004 of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program aboard the NOAA ship David Starr Jordan. The CalCOFI program was organized in the late 1940s to study the causes of variations in population size of fishes of importance to the State of California. It is carried out by NOAA's National Marine Fisheries Service Southwest Fisheries Science Center, the California Department of Fish and Game, and the Marine Life Research Group (MLRG) at the University of California's Scripps Institution of Oceanography (SIO). MLRG contributes to this program by investigations of the physical, chemical and biological structure of the California Current. Data from CalCOFI Cruises 9003 and 9004 were collected and processed by personnel of the Marine Life Research Group and the Southwest Fisheries Science Center. Volunteers and other SIO staff members also assisted in the collection of data and chemical analyses at sea.

Included in this report are observations from hydrographic casts, Secchi disk lowerings, primary productivity casts and macrozooplankton net tows. Duplicate samples were collected on several stations and analyzed, either by separate analysts or at different times, in order to assess the field reproducibility of the shipboard measurements; those results are also included.

In addition to the usual horizontal maps of characteristics at the surface and at 200 m, vertical sections of various properties measured on CalCOFI line 90 appear in this report.

STANDARD PROCEDURES

Field Analytical Reproducibility Tests

Seawater analyses are performed at sea by people having a variety of skills and experience. Included are experienced technicians as well as first-cruise volunteers. New technicians and volunteers usually receive practice samples and 10-20 replicate oxygen samples to analyze at the beginning of a cruise, in order to familiarize them with the equipment and to assess their analytical precision, before permitting them to analyze real samples. An experienced technician can routinely achieve a precision of 0.1% on 10 surface seawater oxygen replicates (each flask has a different volume, so the analyst cannot titrate to an "expected" value). However, that precision is not likely to be achieved on routine samples given adverse sea conditions and a sampling rate of 100 or more samples per day, which are not likely to be run quite as carefully as are the replicate check samples. Some indications of the routine field precision may be seen from examination of station data that have several (5 to 8) samples in deep mixed layers which often occur on the outer stations. However, those data do not cover the full range of observations; they are likely to be low in nutrients and chlorophyll and near saturation in oxygen.

A more realistic evaluation of field analytical reproducibility was obtained on the 1990 CalCOFI cruises by collecting about 100 duplicate samples from all depths from several stations and by having different individuals, when feasible, analyze the samples at different times. The complete results are shown in Tables 1-8.

Hydrographic Cast Data

The hydrographic casts usually consisted of 20 three-liter plastic (PVC) bottles lowered to a maximum sampling depth of 525 meters, bottom depth permitting. Temperature, salinity, oxygen and nutrients were determined at sea for all depths sampled. Chlorophyll-a and phaeopigments were usually determined at sea from the top 14 depths. A special near-bottom cast was done in the Santa Barbara Basin on each cruise.

Paired protected reversing thermometers read by two observers were used to determine temperatures which were then recorded to hundredths of a degree Celsius. The temperatures are reported relative to the International Practical Temperature Scale of 1968 (IPTS-68). The new International Temperature Scale of 1990 (ITS-90) differs from the IPTS-68 by less than 0.01° C over oceanic temperature ranges, so the distinction between the two scales is of marginal significance for temperatures listed to the nearest hundredth of a degree. Most sampling bottles used below a depth of about 75 meters were equipped with unprotected thermometers for determination of the depth of sampling, using the Saunders (1981) pressure-to-depth conversion technique.

* The first two digits represent the year and the last digits the month of the cruise.

Salinity samples were analyzed at sea using inductive-type salinometers standardized with substandard seawater. Periodic checks on the concentration of the substandard were made by comparison with IAPSO Standard Seawater batch P-78. Salinity values have been calculated from the algorithms for the Practical Salinity Scale, 1978 (UNESCO, 1981a) and were reported to three decimal places, provided that accepted standards were met If only one determination per sample was obtained, or there was doubt concerning the accuracy of the analytical results, the salinities were reported to two decimal places. Duplicate salinity analyses (Table 1), performed by different analysts, typically agree within 0.002 PSU.

Dissolved oxygen was determined by the Winkler method, as modified by Carpenter (1965), using the equipment and procedure outlined by Anderson (1971). Percent oxygen saturation was calculated from the equations of Weiss (1970). Duplicate oxygen samples, (Table 2) analyzed by different analysts, typically agreed within 0.02 mtyl.

Silicate, phosphate, nitrate and nitrite nutrients were determined at sea using an automated analyzer. The procedures used are similar to those described in Atlas *et al.* (1971). Typical agreement between duplicate nutrient analyses was 0.5 for silicate, 0.01 for phosphate, 0.1 for nitrate and 0.01 for nitrite even for samples held overnight in a refrigerator and run the next day (Tables 3-6). Precision was degraded by a factor of ten when samples were frozen and then analyzed ashore.

Chlorophyll-a and phaeopigments were measured with a fluorometric technique (Yentsch and Menzel, 1963; Holm-Hansen *et al.,* 1965) from subsamples filtered onto GF/F filters which have a specified minimum retention size of 0.7jim. Prior to CalCOFI cruise 8907, GF/C filters with a nominal minimum retention size of 1.2|um were used. Comparisons between the two sizes of filters indicate that the finer filter retains about 15% more pigment at chlorophyll-a concentrations of less than 0.5 mg/m , but with no obvious bias between the two at higher concentrations (Venrick and Hayward, 1984). Other field experiments showed losses by the 1.2um filter on the order of 4 to 9% (Venrick *et al.,* 1987). The pigments were extracted with a cold extraction technique in 90% acetone (Venrick and Hayward, 1984) and the fluoresence determined before and after acidification with a fluorometer. Results from duplicate chlorophyll and phaeopigment analyses, performed by different analysts, are shown in Tables 7 and 8.

The observed data have been evaluated using the methodology described by Klein (1973). This involves consideration of their variation as functions of density or depth and their relations to each other, and comparisons with adjacent observations.

Primary Production

Primary productivity casts were taken each day shortly before local apparent noon (LAN). Primary production was estimated from C uptake using a simulated *in situ* technique. Light penetration was estimated from the Secchi depth (assuming that the 1% light level is three times the Secchi depth). Six depths, corresponding to predetermined levels of light penetration, were sampled with 5-liter Niskin bottles. Where the productivity casts occurred at nonstandard CalCOFI sampling locations, additional hydrographic bottles were added to extend the observations to 200 m. Temperature, salinity, oxygen, nutrients, chlorophyll-a and phaeopigments were determined for all depths sampled. Triplicate samples (two light and one dark control) were collected from each productivity sample depth into 250-ml polycarbonate incubation bottles which were then innoculated with approximately lOjiCi of C as NaHCO,. These were incubated from LAN until civil twilight in seawater-cooled incubators with neutral-density screens which simulate the *in situ* light levels. At the end of the incubation, the samples were filtered onto HA millipore filters and placed in scintillation vials. One-half ml of 10% HC1 was added to each sample. The sample was then allowed to sit, without a cap, at room temperature for 12 hours (after Lean and Burnison, 1979). Following this, 10 ml of scintillation fluor were added to each sample and the samples were returned to SIO where the radioactivity was determined with a scintillation counter.

Macrozooplankton Net Tows

Macrozooplankton was sampled with a 71-cm mouth diameter paired net (bongo net) equipped with 0.505-mm plankton mesh. Bottom depth permitting, the nets were towed obliquely from 210 m to the surface. The tow time for a standard tow was 21.5 minutes. Volumes filtered were determined from flowmeter readings and the mouth area of the net. Only one sample of each pair was retained and preserved. The biomass, as wet displacement volume, after removal of large (>5-ml) organisms, was determined in the laboratory ashore. These procedures are summarized in greater detail in Kramer *et at.* (1972).

TABULATED DATA

Field Analytical Reproducibility Tests

Results from duplicate salinity, oxygen, silicate, phosphate, nitrate, nitrite, chlorophyll-a and phaeopigment analyses are shown in Tables 1 to 8, respectively. The origin of the samples is indicated by the cruise, station, depth and cast time in PST, and the local times of each analysis. Except for salinity, the results from both sets of analyses are listed to one extra decimal place beyond that normally reported, and the difference (1st-2nd) is listed so that the units place represents the least reported decimal place. For example, oxygen is normally reported to the nearest 0.01 ml/l, so the tabulated difference is multiplied by 100 so that one may easily see differences in last significant figure. As a summary statistic, we give the mean of the differences between replicate determinations (D = replicate 1 - replicate 2) and its standard deviation. Analytical bias is indicated by the degree to which D differs from zero. Precision is indicated by the standard deviation. The reproducibility of chlorophyll and phaeophytin is a function of the mean concentration. For these we give this function for |D| and its standard deviation as determined from two regression analyses, both significant at $p < .0005$.

Hydrographic Cast Data

The reported hydrographic cast time is the Coordinated Universal Time (UTC) of the messenger release. Bottom depths, determined acoustically, have been corrected using British Admiralty Tables (Carter, 1980) and are reported in meters. Weather conditions have been coded using WMO code 4501.

Observed and interpolated standard depth data from hydrographic casts have been interspersed and are presented together sequentially by depth. Interpolated or extrapolated standard level data are noted by the footnote "ISL" printed after the depth. Density-related parameters have been calculated from the International Equation of State of Seawater 1980 (UNESCO, 1981, b). Computed values of potential temperature, sigma-theta, specific volume anomaly (SVA), dynamic height or geopotential anomaly, and pressure are included with both observed and interpolated standard depth levels.

Primary Production

In addition to the normal hydrographic data, the tabulated data include: the light level at which the samples were incubated, the uptake from each of the replicate light bottles (uptake 1 and uptake 2) which have been corrected for dark uptake by subtracting the dark value, the mean of the two uptake values, the dark uptake, chlorophyll-a and phaeopigments. The uptake values shown are the total for the incubation period. Also shown are the times of local apparent noon (LAN), civil twilight, and the vertically integrated value of the mean uptake from the surface to the deepest sample, assuming that the shallowest measured value extends to the surface and that the negative values (when dark uptake exceeds light uptake) are zero. The uptake data have been presented to two significant digits (values <1.00) or one decimal (values >1.00). The higher production values may not warrant all of the digits presented. Incubation time, LAN, and civil twilight are given in local Pacific Standard Time (PST); to convert to UTC, add eight hours to the PST time.

Secchi Disk Observations

Secchi disk observations were made on most daylight stations. The times are given in local PST (+8) time. Weather codes, cloud observations, and Forel water color are also presented.

Macrozooplankton Data

Macrozooplankton biomass volumes are tabulated as total biomass volume ($cm^3/1000\ m^3$ strained) and as the total volume minus the volume of larger organisms under the heading "Small." Tow times are given in local PST (+8) time.

FOOTNOTES

In addition to footnotes, special notations are used without footnotes because the meaning is always the same.

ISL: After depth values indicates interpolated or extrapolated standard level.

P: After depth values indicates the bottle posttripped.

U: Uncertain value. Values which are not used in interpolation because they seem to be in error without apparent reason.

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