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Physical, Nutrient, and Biological Measurements of  
Coastal Waters off Central California in January 2009

by

Thomas A. Rago, Reiko Michisaki, Baldo Marinovic, Marguerite Blum, and  
Katherine Whitaker

November 2009

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## **Introduction**

Following in a long tradition of hydrographic studies of the California Current system-- see, for example, Steger *et al.* (2000) and Collins *et al.* (2003)-- the data in this report were collected during the 20-23 January 2009 cruise of the Pacific Coast Ocean Observing System (PaCOOS) program aboard the *R/V Western Flyer*, supplemented by other data collected about a week later during a Naval Postgraduate School (NPS) student cruise aboard the *R/V Point Sur* from 29 January to 4 February 2009. The PaCOOS program was organized in 2003/2004 as the NOAA west coast contribution to the national Integrated Ocean Observing System (IOOS), and is charged with “providing ocean information for the sustained use of the California Current Large Marine Ecosystem under a changing climate.”<sup>1</sup> PaCOOS cruises generally subsample the standard California Cooperative Oceanic Fisheries Investigations (CalCOFI) grid of hydrographic stations (Figure 1). This PaCOOS cruise did exactly that, sampling along CalCOFI line 67 from station 90 to Moss Landing, California [CTD casts 1, 2w-10] (Figure 2). Additionally, the NPS cruise augmented the PaCOOS data by sampling along both CalCOFI line 67 (stations C1, H3, 52.5, 55, 57.5, and 60) [CTD casts 2s, 12-15, 41], and CalCOFI line 60 from Drake’s Bay to station 60 [CTD casts 29-33] (Figure 2). These data now add to those from similar recent PaCOOS cruises (Rago *et al.*, 2006, 2007a, 2007b, 2007c, 2008a, 2008b, 2009). Participants on the two cruises came from the Naval Postgraduate School (Physical Oceanography, Marine Mammal Observations), the Monterey Bay Aquarium Research Institute (Physical Oceanography, Nutrient Analysis and Primary Productivity), University of California at Santa Cruz (Zooplankton Analysis), Moss Landing Marine Laboratories (Physical Oceanography), and Monterey Peninsula College (Nutrient Analysis).

The discussions that follow this introduction will generally refer to the PaCOOS cruise and its data. However, except that primary productivity, zooplankton analyses, and marine mammal observations were not performed during the NPS cruise, unless otherwise noted, these discussions will apply equally well to the NPS cruise and its data.

## **Standard Procedures**

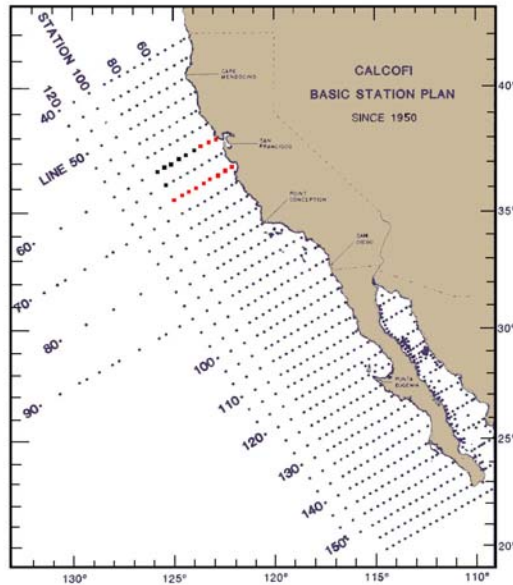
### *CTD/Rosette Data:*

At each site a Seabird Electronics, Inc., Conductivity-Temperature-Depth (CTD) instrument fitted with a 12-place rosette was deployed. The rosette was equipped with 12 10-liter PVC Niskin bottles for collection of water samples. The CTD was lowered to 1000 meters or the bottom (whichever came first). Where primary productivity sampling was performed (the PaCOOS cruise), water samples were taken at depths designed to maximize resolution of the variables sampled throughout the thermocline. Otherwise (the NPS cruise), water samples were collected so as to aid in the later conductivity/salinity calibration of the CTD conductivity sensors. A water sample was always obtained at or near the bottom of each CTD cast for that later conductivity/salinity calibration.

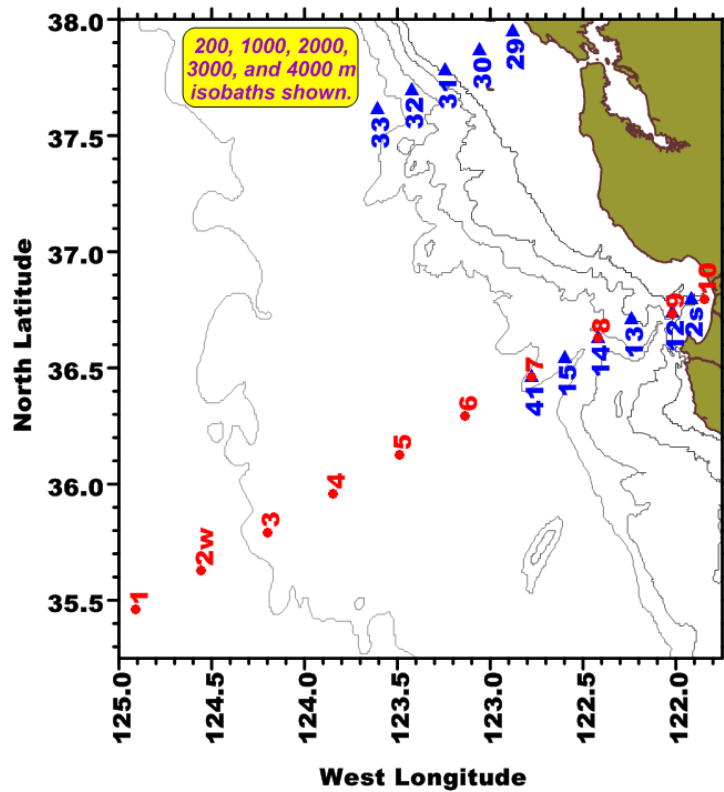
Besides temperature (dual sensors), conductivity (dual sensors), and pressure, the CTD also measured fluorescence, transmissivity, dissolved oxygen content, and photosynthetically available radiation (PAR) in the water column. Except for PAR and the secondary of the dual sensors, all these parameters are reported here.

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<sup>1</sup> <http://www.pacoos.org>



**Figure 1:** Full CalCOFI hydrographic station grid. Stations occupied during the PaCOOS and NPS cruises of January (and February) 2009 are highlighted in red.



**Figure 2:** Hydrographic stations occupied during the PaCOOS (red circles) and NPS (blue triangles) cruises of January (and February) 2009. 200, 1000, 2000, 3000, and 4000 m isobaths are shown. Net tows were completed at sites 1, 3, 5, 7, 9, and 10.

Generally, a minimum of two salinity samples (including the bottom-of-cast sample) were collected from each CTD cast. These samples were analyzed after the cruise at the Monterey Bay Aquarium Research Institute (MBARI) using a Guildline model 8400B Autosal salinometer. A regression between the salinometer results and the conductivities measured by the CTD at the times the Niskin bottles were tripped was made, from which a correction to the CTD salinities was determined and then applied. The salinometer was standardized using IAPSO Standard Seawater (batch P148) before and after each set of water samples was analyzed. Salinity values were calculated using the algorithms for the Practical Salinity Scale, 1978 (UNESCO, 1981).

Dissolved oxygen (Winkler) samples were collected at CTD stations 1, 5, 8, and 9 (PaCOOS) and 9s, 16, and 32 (NPS). (The data from only the last NPS CTD station are included in this report.) These were analyzed after the cruise at MBARI. The CTDs for these cruises were outfitted with Sea-Bird Electronics, Inc., SBE 43 oxygen sensors. This sensor is a polarographic membrane that outputs a voltage proportional to the temperature-compensated current flow occurring when oxygen is reacted inside the membrane. Dissolved oxygen concentration is then calculated from a modified version of the algorithm by Owens and Millard (1985). The results of the analysis of the Winkler oxygen samples were compared to the corresponding oxygen values recorded by the CTD. Using the method described in SBE Application Note #64-2<sup>2</sup>, we calculated new SBE 43 sensor coefficients. Corrected CTD oxygen values were then recalculated with the modified version of the Owens and Millard (1985) algorithm using the new sensor coefficients.

For these cruises, the CTDs were fitted with Seatech<sup>3</sup> 25-cm. transmissometers. This instrument is designed to measure beam transmission over a 25 centimeter water path using a modulated Light Emitting Diode (660 nm, in this case) and a synchronous detector. The temperature compensated transmissometer is not sensitive to ambient light. (For further details concerning the Seatech transmissometer, the introduction from its operating manual is reprinted in Appendix C.)

Nutrient samples were collected during the PaCOOS cruise in 45-ml polypropylene screw-capped containers which were rinsed three times prior to filling. Samples were frozen and returned to MBARI for later analysis on an AlpChem autoanalyzer, as in Sakamoto *et al.* (1990).

Chlorophyll-*a* and phaeopigments were collected during the PaCOOS cruise in 280-ml polyethylene bottles and filtered onto 25-mm Whatmann GF/F filters. Chlorophyll-*a* was assayed with the standard fluorometric procedure of Holm-Hansen *et al.* (1965), modified such that phaeopigments are extracted in acetone in a freezer over at least 24 hours (Venrick and Hayward, 1984; Chavez *et al.*, 1991). Analysis was performed as possible during the cruise or at MBARI immediately following the cruise.

Primary productivity during the PaCOOS cruise was estimated for the 100, 50, 30, 15, 5, 1, and 0.1% light penetration depths as determined by secchi, and followed the general method of Parsons *et al.* (1984). Water samples from the appropriate depths were collected in 280-ml polycarbonate bottles, spiked with <sup>14</sup>C, and incubated on deck for 24 hours under running seawater in plexiglass tubes wrapped with nickel-cadmium screens of differing pore size. (See Pennington and Chavez, 2000, for methodology details.)

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<sup>2</sup>See **Application notes** under the **Support** tab at <http://www.seabird.com>.

<sup>3</sup> Seatech, Inc. was acquired by Wet Labs, Inc., in late 1998.

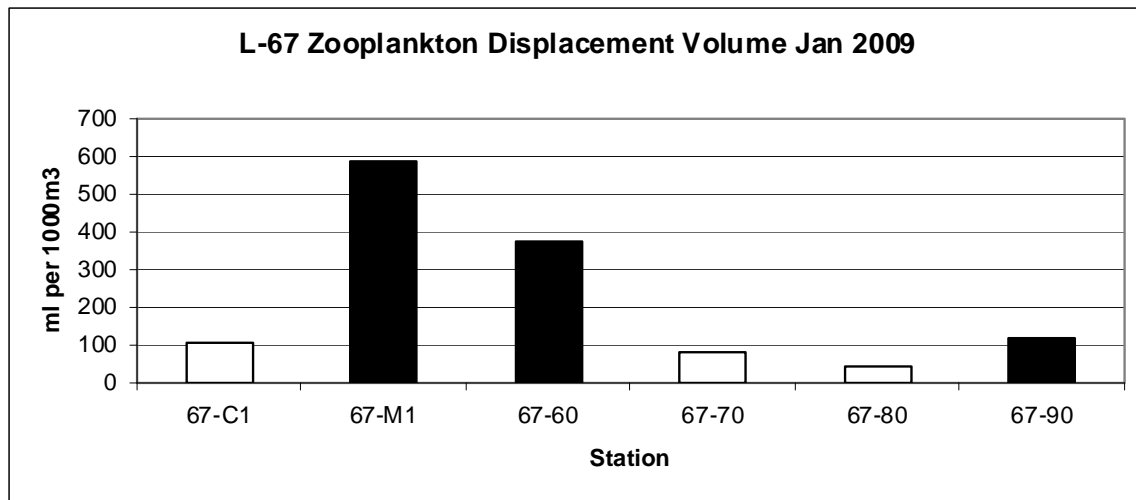
### Zooplankton Net Tows:

Six stations<sup>4</sup> (Figure 2 and Table1) along CalCOFI Line 67 were sampled for zooplankton abundance during the cruise. All sampling was conducted with 0.7-m diameter paired bongo nets fitted with 505-mm mesh, which were towed obliquely to a depth of 210 m (or within 10 m of the bottom, whichever came first). Samples were preserved at sea according to standard protocols (Kramer *et al.*, 1972). Zooplankton biomass was distinctly higher in the inshore portion of the line (Figure 3). Euphausiid abundance was relatively low, with similar peak abundances occurring in the inshore portion of the line (Table 1). *Euphausia pacifica* was the most abundant species of krill, with the size structure of the population sampled consisting predominantly of mature adults (Fig. 4). *Nematoscelis difficilis* was second highest in abundance and had a more offshore distribution.

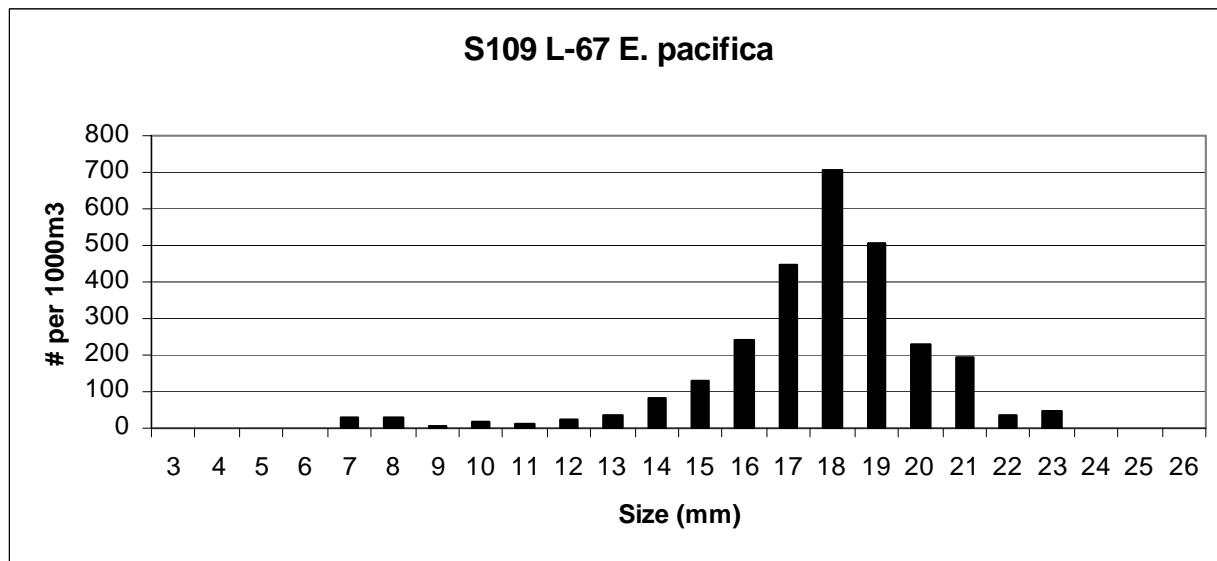
**Table 1:** *Zooplankton data.* This table lists the total biovolume (displacement) abundance, as well as the biovolume abundance for the three most common species of euphausiids, measured at the six hydrographic stations sampled by bongo net tows along CalCOFI line 67 during the PaCOOS cruise of January 2009. The data are listed onshore to offshore. (Units are ml/1000 m<sup>3</sup> of seawater filtered for total displacement, and individuals per 1000 m<sup>3</sup> of seawater filtered for euphausiid species.)

Station (CalCOFI) Number	Displacement Volume (ml/1000m <sup>3</sup> )	<i>E. pacifica</i> Volume (#/1000m <sup>3</sup> )	<i>N. difficilis</i> Volume (#/1000m <sup>3</sup> )	<i>T. spinifera</i> Volume (#/1000m <sup>3</sup> )
10 (67-C1)	108.05	241.32	0.00	7.20
9 (67-M1/H3)	590.61	11043.90	0.00	0.00
7 (67-60)	376.44	5844.04	162.79	0.00
5 (67-70)	78.61	1.97	17.69	0.00
3 (67-80)	43.16	1.92	5.75	0.00
1 (67-90)	116.26	500.48	128.44	0.00

<sup>4</sup> CTD stations 1, 3, 5, 7, 9, and 10.



**Figure 3:** Zooplankton displacement volumes collected at six hydrographic stations along CalCOFI line 67 during the PaCOOS cruise of January 2009. Samples are arranged onshore (67-C1) to offshore (67-90), with nighttime sampling shown by black bars.

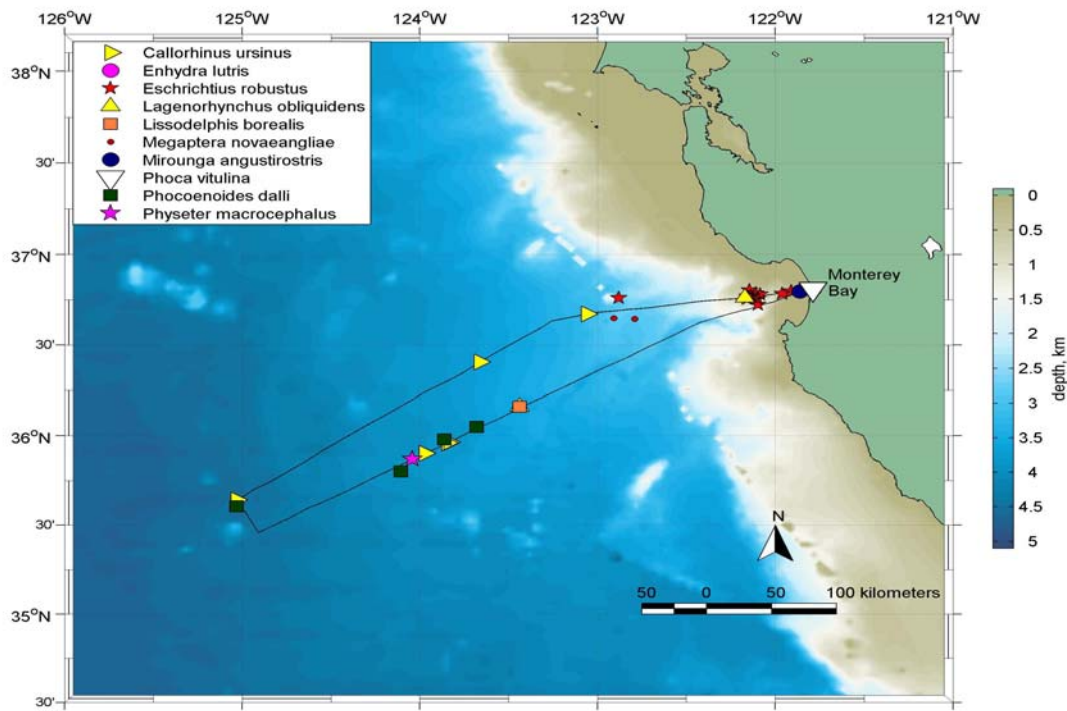


**Figure 4:** Cumulative population size structure for *E. pacifica* collected at six hydrographic stations along CalCOFI line 67 during the PaCOOS cruise of January 2009.

*Marine Mammal Observations:*

Observations of marine mammals (Figure 5, Tables A4 and A5) were made by a single observer during daylight hours (approximately 1500 to 0130 Coordinated Universal Time [UT]) throughout the cruise, conditions permitting (e.g., clear or high clouds, Beaufort state less than 4, etc.).

Observations were made from the 01-deck aft position<sup>5</sup> (above the fantail), where eye height was approximately 9 meters above the sea surface, using handheld Fujinon 7 x 50 binoculars with compass for bearing and reticle for distance. Observations were recorded on a laptop computer using the marine mammal and bird mapping program *Seebird* (developed at the Southwest Fisheries Science Center). This program interfaces with handheld global positioning system (GPS) devices, and allows the generation of observation logs containing the observations of the mammals themselves with matching ship's velocities and positions, observational conditions, etc. Generally, intensive "on effort" observations were made during the last half of each half-hour period, with the other half of the half-hour period devoted to less intensive "off effort" observations. Depending on the situation, the observer would take short breaks from the observations approximately every two hours.



**Figure 5.** Marine mammal sightings during the PaCOOS cruise of January 2009. The black line shows the track of the ship.

#### *Ancillary Observations:*

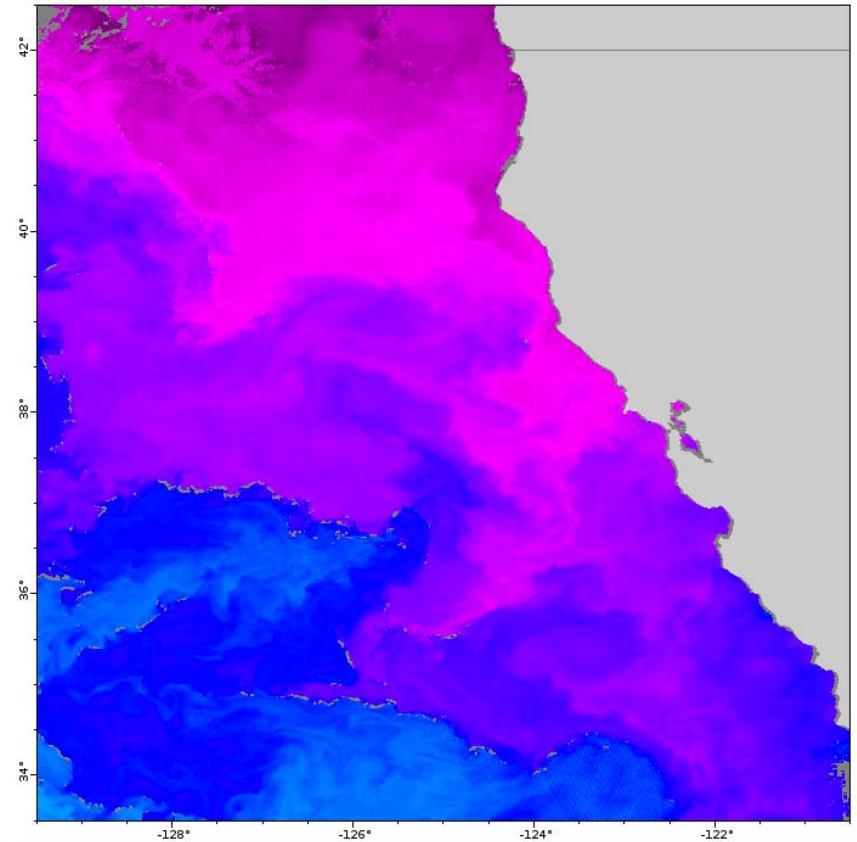
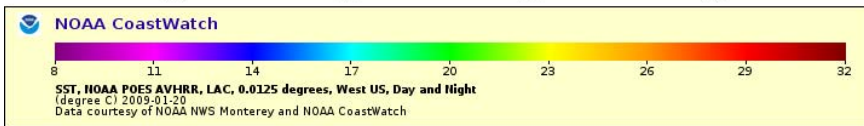
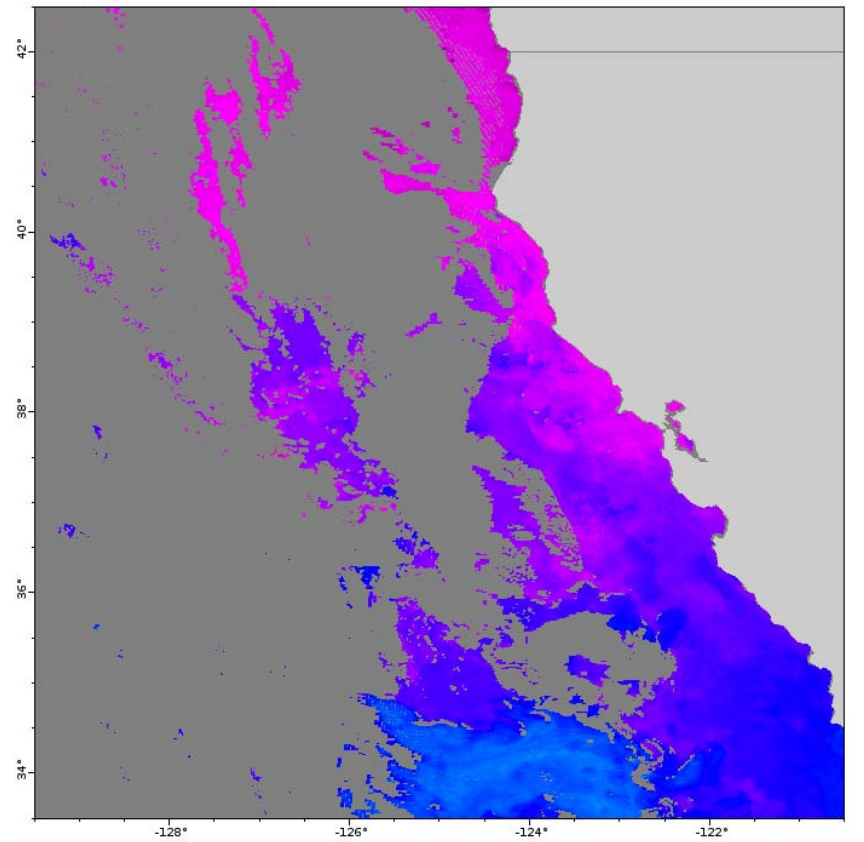
*Underway Data:* Near surface measurements of temperature and salinity were recorded throughout the cruises from water pumped through the ships' uncontaminated seawater systems. These data were recorded at approximately 60-second (30-second) intervals

<sup>5</sup> Observations facing aft are not ideal, since the field of view is partially blocked by the ship itself. This can be (and was) mitigated by maintaining port and starboard watches. Unfortunately, there is no safe out-of-the-way forward-facing location available aboard the *R/V Western Flyer* from which to conduct marine mammal observations.



throughout the PaCOOS (NPS) cruise. Table A1 lists these data at the start of each hydrographic station.

*Satellite Imagery:* Advanced Very High Resolution Radiometer (AVHRR) satellite imagery of sea surface temperature of the area of operation during the PaCOOS and NPS cruises is included as Figure 6.



**Figure 6.** Advanced Very High Resolution Radiometer (AVHRR) satellite imagery of sea surface temperature ( $^{\circ}\text{C}$ ) of the area of operation during the PaCOOS and NPS cruises of January (and February) 2009. The images were taken at 1200 UT on 20 January 2009 (left) and 1 February 2009 (right).

## Tabulated Data (in Appendix A)

The following tables of data can be found in Appendix A:

1) Table A1: Sea Surface Data

This lists the surface oceanographic conditions at the start of each hydrographic station as measured by the underway data acquisition systems of the *R/V Western Flyer* (PaCOOS) and *R/V Point Sur* (NPS).

2) Table A2: Hydrographic Data

This is a chronological listing of the hydrographic data collected at each CTD station during the cruises. Data are given for standard pressures, except that the last line of data for each site is the deepest pressure for that CTD cast. The surface pressure, listed as 0 dbar, is actually 1 dbar. Salinities (oxygen) have been adjusted according to the conductivity/salinity (oxygen) calibration correction determined from the collected salinity (oxygen/Winkler) water samples. The time listed for each station is the beginning (UT) of the CTD cast. Units of geopotential anomaly ( $\Delta\Phi$ ), potential density ( $\sigma_\theta$ ), and potential spiciness ( $\pi_\theta$ ) are  $\text{m}^2\text{s}^{-2}$ ,  $\text{kg m}^{-3}$ , and  $\text{kg m}^{-3}$ , respectively.

3) Table A3: Nutrient and Primary Productivity Data

This is a chronological listing of the results of the nutrient and primary productivity analyses of the water samples collected from the 12 Niskin bottles tripped at each hydrographic station during the PaCOOS cruise of January 2009. The time given is the start (UT) for each hydrographic station. The data for each hydrographic station are separated into three sections (“Physical and Chemical,” “Chlorophyll,” and “Primary Production”).

The physical oceanographic properties listed in the first seven columns of the “Physical and Chemical” section of each station’s data are the uncorrected values measured by the CTD at the times each Niskin bottle was tripped. Because they are uncorrected, these values may differ slightly from those listed in Table A2. The last four columns of this section of each station’s data give the nitrate ( $\text{NO}_3$ ), nitrite ( $\text{NO}_2$ ), phosphate ( $\text{PO}_4$ ), and dissolved silicate ( $\text{SiO}_4$ ) concentrations (determined as described previously).

The “Chlorophyll” and “Primary Production” sections of each station’s data give the results of the primary productivity analyses.

4) Table A4: Marine Mammal Data

This table lists the results of the marine mammal observations made during the PaCOOS cruise of January 2009. The data are listed alphabetically by species’ scientific name, then chronologically within each species.

5) Table A5: Marine Mammal Data Summary

This table summarizes the (more specific) results from Table A4 of the marine mammal observations made during the PaCOOS cruise of January 2009. The data are listed alphabetically by species’ scientific name, except that pinnipeds/southern sea otters are listed last.

## Figures of Results (in Appendix B)

Graphical representations of the data collected during this cruise follow the tabulated data in Appendix A. Figure 7 is a series of four diagrams contouring (a) the temperature ( $^{\circ}\text{C}$ ), (b) the salinity, (c) the density anomaly ( $\text{kg m}^{-3}$ ), and (d) the oxygen ( $\mu\text{mol kg}^{-1}$ ) fields along the lines of hydrographic stations from Moss Landing, California, to CalCOFI 67-90, and from Drake's Bay, California, to CalCOFI 60-60.

Figure 8 contours the fluorescence and transmissivity in the upper 100 meters of the water column along the same lines of hydrographic stations as in Figure 7 from Moss Landing and Drake's Bay, California.

Figure 9 is a series of four diagrams contouring the (a) nitrate ( $\mu\text{M}$ ), (b) nitrite ( $\mu\text{M}$ ), (c) phosphate ( $\mu\text{M}$ ), and (d) silicate ( $\mu\text{M}$ ) fields along the lines of hydrographic stations from Moss Landing and Drake's Bay, California.

Figure 10 contours the chlorophyll-*a* and phaeophytin concentrations in the upper 85 meters of the water column along the lines of hydrographic stations from Moss Landing and Drake's Bay, California.

Finally, Figure 11 contours the primary productivity and the primary productivity index along the lines of hydrographic stations from Moss Landing and Drake's Bay, California. These properties were estimated for the 100, 50, 30, 15, 5, 1, and 0.1% light penetration depths as determined by secchi. These light penetration depths are indicated in the figure.

## Cruise Participants

Personnel	Duties	Affiliation
Tim Pennington (Chief Scientist)	Nutrients, Primary Productivity	Monterey Bay Aquarium Research Institute
<i>Marguerite Blum</i>	<i>Nutrients, Primary Productivity, Oxygens</i>	
Martin Suro	Physical Oceanography	
<i>Alta Anzalone</i>	<i>Nutrients</i>	
Tarry Rago*	Physical Oceanography	Naval Postgraduate School
<i>Katherine Whitaker</i>	<i>Marine Mammal Observer</i>	
Kit Clark	Phytoplankton Net Tows	University of California, Santa Cruz
Aaron Shoemaker	Nutrients	Monterey Peninsula College
Ben Jokinen**	Physical Oceanography	Moss Landing Marine Laboratories

\* Both PaCOOS (*R/V Western Flyer*) and NPS (*R/V Point Sur*) cruises

\*\* NPS (*R/V Point Sur*) cruise only

All others are PaCOOS (*R/V Western Flyer*) cruise only.

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## Appendix A

**Table A1:** *Sea surface data collected during the PaCOOS and NPS cruises of January (and February) 2009.* Listed here are the surface oceanographic conditions as measured by the underway data acquisition system (UDAS) of the *R/V Western Flyer* at the beginning of each hydrographic station occupied during the PaCOOS cruise of January 2009 (1, 2w, 3-10). Also listed are the surface oceanographic conditions as measured by the UDAS of the *R/V Point Sur* at the beginning of each hydrographic station occupied during an NPS cruise that followed by about a week the PaCOOS cruise (2s, 12-15, 29-33, 41). Continuous measurements of the water being pumped through each ship's uncontaminated seawater system ("sea chest") from approximately 3 meters below the surface supplied the data.

Station	Yearday, 2008 (UTC)	SST (°C)	SSS	Surface Transmissivity (Percent)	Surface Chlorophyll- <i>a</i> (mg m <sup>-3</sup> day <sup>-1</sup> )
1	22.3250	13.172	33.035	87.9	8.592
2w	22.5042	13.442	32.998	89.4	6.540
3	22.6486	13.409	33.020	89.4	7.577
4	22.8292	12.378	33.002	89.2	3.052
5	22.9660	12.351	32.969	84.8	8.643
6	23.1042	12.607	33.210	86.8	6.822
7	23.2292	12.397	33.309	86.7	6.960
8	23.3764	12.692	33.416	88.7	5.462
9	23.5042	12.695	33.358	89.5	4.468
10	23.6181	12.480	33.375	87.7	6.082
2s	29.9681	12.074	33.511	90.2	---
12	31.2132	11.942	33.475	92.5	---
13	31.2917	11.791	33.320	92.5	---
14	31.3903	11.831	33.345	92.9	---
15	31.4764	11.662	33.265	91.5	---
29	33.8389	11.130	33.110	72.2	---
30	33.9174	11.089	33.237	84.9	---
31	33.9833	10.894	33.230	90.4	---
32	34.0646	10.924	33.221	82.8	---
33	34.1507	10.326	32.721	91.4	---
41	34.7750	11.938	33.248	91.6	---

**Table A2:** *List at standard pressures of hydrographic data collected during the PaCOOS cruise of January 2009.* Hydrographic data collected at 11 PaCOOS sites during another NPS cruise approximately one week after the PaCOOS cruise are also listed here. Stations are in chronological order, with the last PaCOOS cruise station being CTD 10 on 23 January 2009. For each cast, the surface pressure (listed as 0 dbar) is actually 1 dbar, while the last pressure is the deepest pressure of the cast. Salinities and oxygens have been adjusted according to the calibration corrections determined from the collected salinity and oxygen water samples. The time listed for each station is the beginning (*<mm/dd/yyyy, hhmm>* UTC) of the CTD cast. Units of geopotential anomaly ( $\Delta\Phi$ ), potential density ( $\sigma_\theta$ ), and potential spiciness ( $\pi_\theta$ ) are  $\text{m}^2\text{s}^{-2}$ ,  $\text{kg m}^{-3}$ , and  $\text{kg m}^{-3}$ , respectively.

**Station:** 1 **Date:** 1/22/2009, 0749 **Lat.:** 35° 27.56 N **Long.:** 124° 54.44 W

P(dbar)	T(°C)	S	O <sub>2</sub> ( $\mu\text{m}/\text{kg}$ )	Xmiss(%)	$\Delta\Phi$	$\sigma_\theta$	$\pi_\theta$
0	12.880	33.051	280.5	85.6	0.030	24.907	0.134
10	12.844	33.052	280.1	86.2	0.303	24.915	0.127
20	12.459	33.043	278.2	87.6	0.604	24.983	0.043
30	12.253	33.065	276.2	88.4	0.898	25.039	0.019
50	11.891	33.063	270.3	89.6	1.474	25.107	-0.053
75	11.106	33.083	257.4	90.4	2.176	25.265	-0.186
100	9.593	33.226	222.3	90.8	2.808	25.636	-0.338
125	9.249	33.612	175.6	90.8	3.356	25.994	-0.087
150	8.585	33.769	159.5	90.9	3.833	26.221	-0.069
200	7.976	33.972	123.4	91.0	4.671	26.473	-0.001
250	7.348	34.021	93.8	91.1	5.432	26.602	-0.054
300	6.946	34.059	74.2	91.1	6.144	26.689	-0.080
400	5.964	34.095	50.9	91.2	7.459	26.846	-0.181
500	5.337	34.158	30.7	91.3	8.642	26.973	-0.209
600	4.979	34.273	16.3	91.3	9.718	27.107	-0.159
700	4.628	34.341	13.3	91.2	10.693	27.201	-0.146
800	4.397	34.403	14.8	91.2	11.590	27.276	-0.122
900	4.151	34.430	17.2	91.2	12.438	27.324	-0.128
1000	3.864	34.449	19.9	91.2	13.247	27.369	-0.143
1010	3.841	34.452	20.6	91.2	13.325	27.374	-0.143



Station: 2w Date: 1/22/2009, 1207 Lat.: 35° 37.56 N Long.: 124° 33.27 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	13.143	33.017	276.1	86.3	0.031	24.829	0.161
10	13.147	33.020	275.8	87.6	0.311	24.830	0.163
20	12.960	33.039	269.6	89.1	0.620	24.882	0.140
30	12.227	33.057	262.5	89.7	0.922	25.038	0.008
50	11.458	33.374	263.2	90.0	1.458	25.428	0.113
75	10.585	33.352	231.1	90.5	2.089	25.567	-0.065
100	10.021	33.696	156.4	90.6	2.653	25.932	0.109
125	9.211	33.831	136.1	90.6	3.143	26.171	0.081
150	8.463	33.874	139.5	91.0	3.586	26.322	-0.004
200	7.876	33.991	120.1	91.1	4.400	26.503	-0.000
250	7.262	34.034	86.8	91.1	5.148	26.625	-0.056
300	6.680	34.066	71.2	91.2	5.845	26.730	-0.111
400	5.796	34.104	48.8	91.3	7.129	26.874	-0.195
500	5.291	34.189	27.2	91.3	8.289	27.003	-0.189
600	4.782	34.257	17.2	91.3	9.341	27.116	-0.194
700	4.569	34.350	13.4	91.3	10.298	27.214	-0.145
800	4.250	34.408	15.0	91.3	11.183	27.295	-0.134
900	3.973	34.447	20.4	91.3	12.004	27.356	-0.132
1000	3.749	34.472	24.0	91.3	12.780	27.399	-0.136
1010	3.738	34.474	24.8	91.3	12.856	27.402	-0.135

Station: 3 Date: 1/22/2009, 1537 Lat.: 35° 47.56 N Long.: 124° 11.99 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	13.104	33.039	274.6	87.7	0.031	24.854	0.170
10	13.102	33.041	275.2	87.6	0.309	24.856	0.171
20	13.018	33.040	274.4	87.5	0.617	24.872	0.153
30	12.931	33.042	274.5	87.5	0.924	24.891	0.136
50	10.372	33.038	246.7	90.6	1.486	25.359	-0.353
75	10.356	33.307	222.4	90.7	2.113	25.571	-0.141
100	9.394	33.654	174.2	90.9	2.650	26.003	-0.029
125	9.081	33.846	142.1	91.0	3.124	26.204	0.072
150	8.625	33.937	139.1	91.0	3.562	26.347	0.075
200	7.647	33.972	113.5	91.1	4.369	26.521	-0.049
250	7.159	34.048	83.8	91.2	5.103	26.650	-0.059
300	6.676	34.068	69.4	91.2	5.792	26.732	-0.109
400	5.636	34.145	38.8	91.3	7.043	26.926	-0.182
500	5.372	34.252	20.2	91.3	8.160	27.044	-0.130
600	4.869	34.310	14.7	91.3	9.180	27.149	-0.143
700	4.519	34.349	13.3	91.3	10.122	27.219	-0.151
800	4.261	34.396	14.4	91.3	11.010	27.285	-0.142
900	4.051	34.432	16.9	91.3	11.847	27.336	-0.137
1000	3.794	34.462	21.1	91.3	12.642	27.386	-0.140
1019	3.761	34.467	22.3	91.3	12.788	27.394	-0.139

Station: 4 Date: 1/22/2009, 1953 Lat.: 35° 57.53 N Long.: 123° 50.71 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	12.009	33.024	274.9	87.8	0.029	25.053	-0.061
10	11.959	33.024	274.5	87.6	0.290	25.063	-0.070
20	11.543	33.035	277.1	86.8	0.576	25.148	-0.141
30	11.716	33.234	284.3	85.7	0.853	25.272	0.051
50	11.427	33.261	278.6	87.4	1.385	25.346	0.118
75	9.809	33.062	247.5	90.5	2.026	25.472	-0.432
100	9.645	33.579	170.9	90.7	2.598	25.904	-0.047
125	8.954	33.763	153.3	90.9	3.092	26.159	-0.015
150	8.771	33.882	137.4	90.9	3.547	26.281	0.051
200	8.168	33.994	124.8	91.0	4.379	26.462	0.045
250	7.562	34.024	105.7	91.1	5.148	26.575	-0.021
300	7.101	34.066	78.7	91.2	5.870	26.673	-0.053
400	6.248	34.139	45.1	91.3	7.194	26.845	-0.111
500	5.582	34.211	26.8	91.3	8.387	26.986	-0.137
600	5.162	34.309	15.6	91.2	9.454	27.114	-0.111
700	4.729	34.356	13.4	91.3	10.424	27.202	-0.123
800	4.305	34.384	13.4	91.3	11.327	27.270	-0.148
900	4.114	34.438	17.0	91.2	12.174	27.335	-0.125
1000	3.813	34.467	21.2	91.2	12.970	27.389	-0.134
1010	3.786	34.468	21.6	91.2	13.047	27.393	-0.135

Station: 5 Date: 1/22/2009, 2311 Lat.: 36° 07.56 N Long.: 123° 29.40 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.858	32.985	288.7	82.8	0.029	25.051	-0.120
10	11.706	33.153	288.0	85.0	0.284	25.210	-0.016
20	11.715	33.378	285.9	85.9	0.546	25.383	0.165
30	11.649	33.420	272.3	88.3	0.803	25.428	0.185
50	11.442	33.450	259.3	89.9	1.308	25.490	0.170
75	9.096	33.270	212.5	90.7	1.904	25.749	-0.384
100	9.042	33.587	174.6	90.9	2.436	26.007	-0.140
125	9.357	33.896	124.0	90.7	2.911	26.199	0.156
150	9.080	33.976	107.7	90.7	3.353	26.306	0.174
200	8.587	34.069	87.3	90.9	4.187	26.457	0.169
250	8.101	34.112	72.1	91.0	4.960	26.565	0.128
300	7.506	34.133	60.1	91.1	5.689	26.669	0.056
400	6.397	34.157	43.0	91.2	7.018	26.840	-0.077
500	5.619	34.206	27.3	91.3	8.215	26.978	-0.137
600	5.203	34.298	15.9	91.2	9.297	27.101	-0.114
700	4.856	34.354	13.5	91.2	10.282	27.186	-0.111
800	4.532	34.400	14.0	91.0	11.200	27.259	-0.111
900	4.101	34.418	15.4	91.2	12.059	27.320	-0.142
1000	3.789	34.449	18.3	91.2	12.866	27.377	-0.150
1008	3.778	34.451	18.5	91.2	12.928	27.380	-0.150

Station: 6 Date: 1/23/2009, 0233 Lat.: 36° 17.56 N Long.: 123° 08.09 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	12.078	33.251	290.5	85.6	0.027	25.217	0.134
10	11.935	33.275	288.1	86.0	0.273	25.262	0.125
20	11.703	33.333	274.9	87.1	0.538	25.350	0.126
30	11.641	33.341	268.5	88.2	0.799	25.368	0.121
50	11.294	33.445	246.0	90.4	1.306	25.513	0.138
75	10.064	33.521	181.6	90.6	1.890	25.788	-0.022
100	9.553	33.788	143.8	90.7	2.406	26.082	0.103
125	9.315	33.887	124.3	90.8	2.877	26.199	0.142
150	8.936	33.979	109.4	90.9	3.316	26.331	0.153
200	8.324	34.104	76.3	91.0	4.124	26.524	0.156
250	7.918	34.156	61.2	90.9	4.868	26.627	0.136
300	7.593	34.185	48.7	91.1	5.575	26.698	0.110
400	6.630	34.218	33.8	91.1	6.897	26.858	0.002
500	6.048	34.250	23.7	91.1	8.098	26.960	-0.049
600	5.495	34.293	17.0	91.1	9.207	27.062	-0.085
700	4.970	34.335	14.0	91.3	10.222	27.158	-0.113
800	4.547	34.384	13.8	91.3	11.160	27.245	-0.122
900	4.284	34.414	15.3	91.3	12.039	27.298	-0.127
1000	4.028	34.443	18.0	91.2	12.876	27.348	-0.131
1008	4.019	34.444	18.1	91.2	12.941	27.350	-0.132

Station: 7 Date: 1/23/2009, 0528 Lat.: 36° 27.56 N Long.: 122° 46.64 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.992	33.325	289.8	85.3	0.027	25.290	0.176
10	11.999	33.347	287.8	85.7	0.267	25.306	0.195
20	11.980	33.431	281.8	87.6	0.528	25.375	0.257
30	11.607	33.387	276.1	87.8	0.785	25.410	0.151
50	11.576	33.434	260.6	88.6	1.295	25.453	0.182
75	10.206	33.554	180.5	90.5	1.895	25.790	0.029
100	9.051	33.662	172.0	90.9	2.418	26.064	-0.079
125	9.034	33.942	119.8	90.8	2.875	26.287	0.140
150	8.787	34.014	105.2	90.8	3.301	26.382	0.158
200	7.993	34.057	89.0	91.0	4.091	26.537	0.069
250	7.139	34.051	84.0	91.1	4.827	26.655	-0.060
300	7.005	34.144	54.4	91.2	5.510	26.747	-0.005
400	6.203	34.154	40.1	91.3	6.799	26.863	-0.105
500	5.784	34.246	23.8	91.3	7.980	26.989	-0.085
600	5.013	34.264	17.4	91.3	9.057	27.096	-0.163
700	4.851	34.356	13.6	91.2	10.041	27.188	-0.110
800	4.429	34.404	14.6	91.2	10.956	27.273	-0.119
900	4.092	34.436	17.3	91.2	11.800	27.335	-0.129
1000	3.861	34.462	20.9	91.3	12.596	27.380	-0.133
1009	3.833	34.465	21.6	91.3	12.666	27.385	-0.133

Station: 8 Date: 1/23/2009, 0904 Lat.: 36° 37.62 N Long.: 122° 25.16 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	12.308	33.427	282.4	87.5	0.027	25.309	0.319
10	12.306	33.438	281.0	87.5	0.265	25.318	0.327
20	11.949	33.446	268.9	87.9	0.528	25.392	0.263
30	12.010	33.520	263.8	88.9	0.783	25.439	0.334
50	11.504	33.509	229.3	89.7	1.284	25.524	0.228
75	10.401	33.716	151.4	90.2	1.854	25.883	0.192
100	9.797	33.838	132.9	90.6	2.360	26.080	0.184
125	9.080	33.898	124.7	90.7	2.821	26.245	0.113
150	8.709	33.954	120.5	90.8	3.255	26.347	0.098
200	8.523	34.115	76.2	90.9	4.065	26.503	0.195
250	8.163	34.147	65.5	91.0	4.829	26.583	0.164
300	7.853	34.176	54.6	91.0	5.559	26.653	0.141
400	6.932	34.225	35.3	91.0	6.912	26.823	0.048
500	6.157	34.246	25.2	91.1	8.138	26.943	-0.039
600	5.273	34.248	19.6	91.2	9.254	27.053	-0.146
700	5.053	34.339	14.2	90.8	10.281	27.152	-0.100
800	4.543	34.392	14.2	90.9	11.219	27.251	-0.116
900	4.159	34.421	15.8	91.1	12.088	27.316	-0.135
1000	3.900	34.444	18.5	91.2	12.906	27.362	-0.143
1011	3.871	34.447	18.9	91.2	12.994	27.367	-0.144

Station: 9 Date: 1/23/2009, 1207 Lat.: 36° 44.09 N Long.: 122° 01.21 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	12.302	33.373	278.1	88.3	0.027	25.268	0.275
10	12.202	33.469	276.3	88.7	0.267	25.362	0.331
20	12.097	33.510	271.4	88.8	0.524	25.414	0.343
30	11.832	33.542	256.6	88.4	0.776	25.489	0.317
50	11.622	33.577	239.8	88.8	1.268	25.556	0.304
75	10.821	33.627	182.0	89.9	1.857	25.740	0.196
100	10.490	33.741	153.8	87.9	2.401	25.887	0.227
125	10.124	33.794	136.9	86.7	2.922	25.992	0.204
150	9.575	33.831	133.5	90.5	3.416	26.113	0.140
200	9.001	34.043	92.6	90.5	4.316	26.372	0.213
250	8.576	34.105	75.7	90.6	5.125	26.488	0.195
300	7.988	34.140	60.8	90.6	5.887	26.605	0.132
400	7.004	34.185	42.6	90.7	7.285	26.781	0.026
500	6.467	34.217	32.0	90.7	8.560	26.879	-0.022
600	5.689	34.270	22.3	90.1	9.735	27.021	-0.079
700	5.004	34.342	17.6	89.5	10.780	27.160	-0.104
800	4.654	34.374	18.1	88.8	11.721	27.225	-0.118
900	4.162	34.423	20.3	88.8	12.613	27.317	-0.132
1000	3.930	34.444	22.2	88.8	13.430	27.359	-0.140
1010	3.930	34.444	22.3	88.7	13.510	27.359	-0.140

Station: 10 Date: 1/23/2009, 1451 Lat.: 36° 47.69 N Long.: 121° 50.74 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	12.091	33.513	271.2	87.0	0.026	25.417	0.344
10	12.041	33.545	267.2	88.1	0.254	25.452	0.360
20	11.909	33.568	258.9	88.5	0.503	25.495	0.353
30	11.852	33.574	254.4	88.8	0.750	25.510	0.346
50	11.647	33.590	235.0	88.9	1.238	25.561	0.319
75	11.539	33.603	225.8	88.5	1.841	25.592	0.309
100	11.494	33.609	232.5	85.9	2.440	25.605	0.305
125	11.447	33.614	218.7	86.5	3.038	25.618	0.299
150	11.355	33.623	216.2	85.7	3.633	25.643	0.288
200	9.999	33.801	160.2	75.0	4.748	26.020	0.187
250	8.706	33.980	96.5	77.7	5.671	26.370	0.116
254	8.651	33.987	92.9	77.8	5.739	26.384	0.113

Station: 2s Date: 1/29/2009, 1520 Lat.: 36° 47.58 N Long.: 121° 55.03 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	12.010	33.506	253.7	85.7	0.025	25.427	0.324
10	11.857	33.508	254.4	85.6	0.253	25.457	0.295
20	11.818	33.510	254.0	86.3	0.504	25.466	0.289
30	11.801	33.510	252.0	87.1	0.755	25.470	0.286
50	11.299	33.586	195.7	89.5	1.247	25.622	0.251
75	10.358	33.737	141.3	89.4	1.800	25.907	0.201
100	9.778	33.824	121.4	88.1	2.307	26.073	0.170
125	9.440	33.877	110.6	87.4	2.786	26.170	0.154
150	9.047	33.927	97.1	86.4	3.237	26.273	0.130
200	8.635	34.042	76.4	89.3	4.084	26.429	0.155
250	8.072	34.072	65.1	87.7	4.873	26.538	0.092
300	7.623	34.114	54.8	87.0	5.613	26.637	0.058
366	6.637	34.190	36.6	86.1	6.492	26.834	-0.019

Station: 12 Date: 1/30/2009, 2105 Lat.: 36° 44.12 N Long.: 122° 01.19 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.931	33.471	253.8	87.8	0.026	25.415	0.280
10	11.913	33.471	253.4	87.8	0.256	25.418	0.277
20	11.896	33.471	252.5	88.0	0.511	25.422	0.273
30	11.870	33.472	251.5	87.9	0.766	25.428	0.269
50	11.782	33.474	246.5	88.8	1.274	25.446	0.253
75	10.694	33.616	168.7	90.5	1.880	25.754	0.164
100	10.128	33.775	132.0	90.5	2.412	25.976	0.190
125	9.675	33.885	114.0	90.7	2.901	26.138	0.200
150	9.415	33.933	105.6	90.7	3.365	26.219	0.195
200	8.831	34.048	80.4	90.7	4.229	26.403	0.190
250	8.351	34.105	65.1	90.7	5.025	26.522	0.160
300	7.897	34.140	54.5	91.0	5.778	26.618	0.119
400	7.011	34.173	39.1	91.0	7.174	26.771	0.018
500	6.023	34.227	24.2	90.9	8.430	26.944	-0.071
600	5.386	34.293	18.8	89.5	9.536	27.075	-0.097
700	4.819	34.358	12.7	90.6	10.526	27.193	-0.112
800	4.704	34.369	12.2	90.7	11.458	27.216	-0.116
900	4.270	34.407	18.5	88.0	12.346	27.293	-0.134
1000	3.786	34.453	23.7	85.7	13.174	27.381	-0.147
1011	3.833	34.449	23.2	85.9	13.259	27.372	-0.146

Station: 13 Date: 1/30/2009, 2310 Lat.: 36° 42.54 N Long.: 122° 14.40 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.779	33.296	264.9	87.4	0.027	25.307	0.112
10	11.785	33.297	264.9	87.5	0.266	25.307	0.114
20	11.882	33.382	260.3	87.6	0.530	25.356	0.200
30	11.872	33.440	253.4	87.6	0.789	25.402	0.244
50	10.144	33.342	211.5	90.5	1.286	25.634	-0.150
75	9.934	33.599	161.7	90.6	1.845	25.871	0.018
100	9.501	33.775	135.7	90.8	2.355	26.080	0.084
125	9.377	33.935	106.4	90.8	2.822	26.226	0.190
150	9.012	34.035	86.0	90.6	3.254	26.363	0.209
200	8.771	34.110	72.0	90.8	4.072	26.461	0.230
250	8.194	34.134	62.2	91.1	4.849	26.569	0.159
300	7.642	34.170	48.4	91.2	5.578	26.678	0.105
400	6.856	34.200	33.1	91.2	6.928	26.813	0.018
500	6.029	34.233	22.2	91.2	8.157	26.948	-0.065
600	5.382	34.300	13.7	91.1	9.265	27.081	-0.092
700	4.724	34.349	11.2	91.2	10.256	27.196	-0.130
800	4.354	34.398	12.6	91.2	11.158	27.277	-0.131
900	4.075	34.434	16.1	90.6	11.998	27.335	-0.133
1000	3.767	34.463	19.8	90.6	12.785	27.390	-0.141
1010	3.763	34.464	19.9	90.6	12.861	27.391	-0.141

Station: 14 Date: 1/31/2009, 0122 Lat.: 36° 37.62 N Long.: 122° 25.28 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.813	33.327	263.4	87.5	0.026	25.325	0.144
10	11.831	33.341	263.2	87.7	0.264	25.333	0.158
20	11.853	33.373	260.4	87.9	0.526	25.354	0.187
30	11.863	33.420	256.3	87.9	0.786	25.388	0.226
50	11.705	33.482	237.0	89.3	1.296	25.467	0.245
75	10.335	33.556	174.1	90.5	1.892	25.769	0.053
100	9.749	33.674	149.3	90.7	2.424	25.960	0.046
125	9.299	33.841	125.4	90.8	2.910	26.165	0.103
150	8.914	33.943	106.5	90.8	3.358	26.306	0.121
200	8.504	34.098	78.1	91.0	4.184	26.493	0.179
250	7.989	34.146	57.8	91.1	4.940	26.609	0.138
300	7.556	34.180	45.5	91.2	5.651	26.699	0.101
400	6.755	34.200	32.1	90.8	6.976	26.827	0.004
500	6.024	34.228	22.4	91.2	8.194	26.945	-0.070
600	5.376	34.302	13.3	91.0	9.300	27.083	-0.091
700	4.932	34.336	11.3	91.1	10.309	27.163	-0.117
800	4.526	34.390	12.0	90.9	11.240	27.252	-0.119
900	4.140	34.430	15.0	91.1	12.101	27.325	-0.129
1000	3.832	34.459	18.7	91.3	12.903	27.380	-0.138
1010	3.803	34.462	19.3	91.3	12.981	27.385	-0.139

Station: 15 Date: 1/31/2009, 0327 Lat.: 36° 32.60 N Long.: 122° 35.98 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.650	33.257	268.1	86.6	0.027	25.300	0.057
10	11.652	33.258	268.6	86.7	0.266	25.301	0.057
20	11.650	33.258	268.0	86.7	0.533	25.302	0.057
30	11.666	33.390	263.1	87.0	0.796	25.402	0.165
50	10.521	33.563	180.2	90.4	1.279	25.742	0.092
75	9.887	33.754	136.5	90.5	1.803	25.999	0.133
100	9.588	33.871	118.4	90.6	2.286	26.141	0.175
125	9.016	33.909	118.5	90.7	2.744	26.263	0.111
150	8.933	34.019	92.8	90.8	3.177	26.363	0.185
200	7.953	34.015	93.3	91.0	3.982	26.510	0.030
250	7.895	34.148	57.9	91.1	4.732	26.624	0.126
300	7.481	34.175	45.2	91.1	5.439	26.705	0.086
400	6.737	34.225	28.2	91.2	6.748	26.849	0.022
500	5.665	34.212	22.7	91.3	7.948	26.977	-0.126
600	5.249	34.309	13.1	90.9	9.028	27.104	-0.100
700	4.852	34.349	11.3	91.0	10.016	27.182	-0.115
800	4.484	34.396	12.4	90.9	10.933	27.261	-0.119
900	4.152	34.428	14.7	91.0	11.794	27.322	-0.129
1000	3.861	34.459	18.5	91.1	12.601	27.378	-0.135
1015	3.811	34.463	19.2	91.1	12.718	27.386	-0.137

Station: 29 Date: 2/02/2009, 1207 Lat.: 37° 56.91 N Long.: 122° 52.82 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	10.731	33.080	310.6	63.0	0.026	25.328	-0.255
10	10.610	33.231	277.3	82.1	0.256	25.467	-0.156
20	10.474	33.305	239.2	83.2	0.502	25.548	-0.121
30	10.444	33.484	191.3	86.5	0.735	25.693	0.016
44	10.267	33.573	137.1	70.8	1.046	25.793	0.055

Station: 30 Date: 2/02/2009, 1401 Lat.: 37° 52.00 N Long.: 123° 03.48 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	11.031	33.257	306.0	80.5	0.026	25.413	-0.059
10	10.741	33.258	294.5	81.4	0.253	25.465	-0.111
20	10.664	33.257	278.6	85.0	0.503	25.478	-0.126
30	10.608	33.312	256.0	86.3	0.751	25.530	-0.092
50	10.252	33.516	173.8	87.1	1.220	25.751	0.007
75	9.936	33.672	133.7	84.7	1.758	25.927	0.076
87	9.913	33.717	125.7	80.4	2.004	25.967	0.108

Station: 31 Date: 2/02/2009, 1535 Lat.: 37° 46.83 N Long.: 123° 14.63 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	10.889	33.252	280.6	85.2	0.025	25.435	-0.088
10	10.738	33.247	279.6	85.6	0.253	25.457	-0.120
20	10.693	33.352	251.3	87.7	0.500	25.547	-0.044
30	10.709	33.488	222.2	88.7	0.738	25.650	0.066
50	10.500	33.646	169.2	88.3	1.188	25.811	0.154
75	10.095	33.762	126.2	87.0	1.710	25.970	0.175
100	9.827	33.825	112.7	87.4	2.209	26.066	0.179
125	9.548	33.885	102.1	88.1	2.690	26.159	0.178
126	9.546	33.885	101.9	88.1	2.709	26.159	0.178



Station: 32 Date: 2/02/2009, 1735 Lat.: 37° 41.68 N Long.: 123° 25.43 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	10.900	33.234	284.5	78.0	0.026	25.418	-0.101
10	10.843	33.235	281.4	79.0	0.255	25.429	-0.111
20	10.745	33.245	277.4	83.3	0.508	25.454	-0.121
30	10.702	33.259	271.9	85.0	0.759	25.473	-0.117
50	10.514	33.417	214.5	88.7	1.250	25.629	-0.026
75	10.437	33.661	157.9	89.1	1.813	25.834	0.155
100	9.956	33.774	124.2	88.3	2.335	26.004	0.160
125	9.580	33.843	113.3	89.2	2.824	26.121	0.151
150	9.034	33.876	114.1	90.5	3.288	26.235	0.087
200	7.992	33.994	105.6	91.0	4.118	26.488	0.019
250	7.670	34.044	71.6	91.0	4.884	26.575	0.010
300	7.214	34.080	59.7	91.1	5.612	26.668	-0.027
400	6.104	34.090	46.9	91.2	6.947	26.825	-0.167
500	5.361	34.150	29.8	91.3	8.149	26.964	-0.212
600	5.104	34.263	14.4	91.3	9.244	27.084	-0.154
700	4.765	34.331	11.3	91.2	10.244	27.177	-0.139
800	4.399	34.371	11.0	91.3	11.167	27.250	-0.148
900	4.075	34.412	12.8	91.3	12.036	27.317	-0.150
1000	3.675	34.442	15.6	91.3	12.839	27.382	-0.167
1010	3.664	34.447	16.1	91.3	12.916	27.387	-0.164

Station: 33 Date: 2/02/2009, 1941 Lat.: 37° 36.67 N Long.: 123° 36.49 W

P(dbar)	T(°C)	S	O <sub>2</sub> (µm/kg)	Xmiss(%)	ΔΦ	σ <sub>θ</sub>	π <sub>θ</sub>
0	10.402	32.744	280.3	86.5	0.028	25.123	-0.583
10	10.399	32.744	280.2	86.5	0.283	25.124	-0.584
20	10.292	32.739	275.7	87.0	0.566	25.138	-0.607
30	9.564	32.848	257.4	90.0	0.838	25.344	-0.644
50	10.369	33.198	261.7	89.7	1.349	25.483	-0.226
75	8.813	33.283	194.7	90.8	1.938	25.804	-0.419
100	9.217	33.733	144.3	90.7	2.447	26.093	0.004
125	8.951	33.820	135.3	90.8	2.912	26.204	0.030
150	8.766	33.935	109.2	90.7	3.350	26.323	0.091
200	8.240	33.995	103.3	90.9	4.179	26.452	0.057
250	7.786	34.030	89.2	91.0	4.958	26.547	0.016
300	7.341	34.076	65.9	91.1	5.695	26.647	-0.012
400	6.338	34.122	42.4	91.2	7.040	26.820	-0.112
500	5.715	34.195	25.9	91.2	8.257	26.957	-0.134
600	5.002	34.202	19.5	91.2	9.368	27.048	-0.213
700	4.620	34.291	12.0	91.2	10.389	27.162	-0.186
800	4.308	34.368	10.9	91.2	11.318	27.257	-0.160
900	4.076	34.408	12.8	91.2	12.178	27.314	-0.153
1000	3.764	34.445	16.3	91.2	12.986	27.376	-0.156
1011	3.733	34.445	16.3	91.3	13.072	27.379	-0.159

Station: 41 Date: 2/03/2009, 1037 Lat.: 36° 27.56 N Long.: 122° 46.54 W

P(dbar)	T(°C)	S	O <sub>2</sub> ( $\mu\text{m/kg}$ )	Xmiss(%)	$\Delta\Phi$	$\sigma_{\theta}$	$\pi_{\theta}$
0	11.823	33.336	272.5	84.2	0.026	25.330	0.152
10	11.768	33.383	270.2	85.1	0.261	25.377	0.179
20	11.753	33.393	266.8	86.9	0.520	25.387	0.184
30	11.711	33.399	261.8	89.0	0.778	25.400	0.180
50	10.430	33.372	206.5	90.6	1.278	25.609	-0.076
75	9.976	33.624	154.6	90.7	1.832	25.883	0.045
100	9.488	33.827	126.0	90.8	2.334	26.123	0.124
125	8.736	33.900	126.2	91.0	2.783	26.300	0.060
150	8.544	34.020	95.9	90.9	3.200	26.425	0.124
200	7.992	34.057	82.2	91.0	3.986	26.538	0.069
250	7.350	34.075	68.3	91.1	4.722	26.644	-0.011
300	7.293	34.182	41.7	90.9	5.414	26.737	0.065
400	6.555	34.224	27.2	91.0	6.702	26.872	-0.004
500	5.936	34.268	17.8	91.3	7.878	26.988	-0.049
600	5.290	34.307	13.8	90.8	8.950	27.098	-0.098
700	4.726	34.358	11.3	91.0	9.929	27.203	-0.122
800	4.438	34.400	12.6	90.9	10.830	27.269	-0.121
900	4.142	34.426	14.5	91.1	11.683	27.322	-0.132
1000	3.859	34.459	18.5	91.1	12.486	27.378	-0.136
1013	3.825	34.461	19.0	91.1	12.588	27.383	-0.137

**Table A3:** Results of nutrient and primary productivity analyses of water samples collected at each hydrographic station during the PaCOOS cruise of January 2009. Stations are in chronological (and numerical) order. The time listed (<Mon. dd, yyyy hh:mm> UT) for each station is the beginning of the CTD cast. 12 Niskin bottles were tripped at each station. The data for each station are separated into three sections (“Physical and Chemical,” “Chlorophyll,” and “Primary Production”).

The physical oceanographic properties listed in the first seven columns of the “Physical and Chemical” section of each station’s data are the uncorrected values measured by the CTD at the times each Niskin bottle was tripped. Because they are uncorrected, these values may differ slightly from those listed in Table A2. The last four columns of this section give the nitrate (NO<sub>3</sub>), nitrite (NO<sub>2</sub>), phosphate (PO<sub>4</sub>), and dissolved silicate (SiO<sub>4</sub>) concentrations.

The “Chlorophyll” and “Primary Production” sections of each station’s data give the results of the primary productivity analyses.

**Cruise:** S109                      **Date GMT:** Jan 22, 2009 15:49                      **Latitude:** 35.459                      **Year:** 2009  
**Station:** 67-90                      **Project:** PACOOS                      **Longitude:** -124.907                      **Day of Year:** 22  
**Cast:** 1                      **Platform:** WESTERN FLYER                      **Secchi depth (m):** 10

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	0.5	12	12.861	33.029	24.894	86	1.958	0.102	0.400	3.891
5	6.1	11	12.864	33.029	24.893	87	---	---	---	---
10	11.5	10	12.813	33.027	24.902	87	2.084	0.155	0.538	3.717
20	20.4	9	12.357	33.039	25.000	88	3.533	0.246	0.567	4.479
30	31.9	8	12.200	33.043	25.033	89	4.573	0.272	0.652	4.853
40	39.3	7	11.937	33.045	25.084	90	5.526	0.368	0.646	5.297
60	61.8	6	11.691	33.057	25.139	90	7.252	0.424	0.839	6.321
80	81.1	5	10.415	33.025	25.341	91	12.841	0.051	1.061	10.512
100	99.7	4	9.639	33.162	25.579	91	16.775	0.029	1.369	14.778
150	151.0	3	8.559	33.754	26.214	91	25.180	0.040	1.904	26.907
200	201.4	2	7.976	33.949	26.455	91	29.217	0.021	2.165	35.762
1000	1007.4	1	3.849	34.448	27.370	92	44.780	0.074	3.370	118.39

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.780	0.240
5	11	0.780	0.204
10	10	0.761	0.258
20	9	0.733	0.330
30	8	0.547	0.277
40	7	0.434	0.214
60	6	0.296	0.172
80	5	0.119	0.099
100	4	0.049	0.058
150	3	0.008	0.031
200	2	0.003	0.019
1000	1	0.001	0.003

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	21.806	27.970	0
50	11	31.417	40.299	6
30	11	31.626	40.566	10
15	10	22.526	29.607	16
5	9	8.355	11.404	25
1	8	1.606	2.938	39
0.1	7	0.000	0.000	64

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll *a*: 28.22 mg m-2 day -1                      Carbon Fixation: 651.13 mg m-2 day-1  
Phaeophytin: 10.55 mg m-2 day -1                      Productivity Index: 23.08 mg C mg Chl M-2 day-1

\* Abbreviations: **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll *a*, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 22, 2009 20:08      **Latitude:** 35.626      **Year:** 2009  
**Station:** 67-85      **Project:** PACOOS      **Longitude:** -124.555      **Day of Year:** 22  
**Cast:** 2      **Platform:** WESTERN FLYER      **Secchi depth (m):** 10

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	1.7	12	13.159	33.005	24.816	88	2.108	0.135	0.444	3.706
5	6.3	11	13.160	33.004	24.816	88	2.112	0.172	0.510	3.241
10	11.3	10	13.162	33.005	24.816	88	2.057	0.161	0.554	3.192
20	22.0	9	13.126	33.035	24.847	89	2.944	0.179	0.528	3.383
30	32.1	8	12.372	33.025	24.986	90	5.720	0.277	0.593	4.919
40	41.5	7	11.419	33.236	25.328	89	7.201	0.307	0.777	7.781
60	62.3	6	11.485	33.377	25.426	91	10.273	0.602	1.008	9.827
80	81.2	5	10.022	33.305	25.626	91	18.307	0.044	1.414	15.563
100	101.2	4	9.926	33.697	25.949	91	23.770	0.053	1.794	22.043
150	150.8	3	8.396	33.844	26.309	91	27.118	0.042	1.943	29.570
200	202.0	2	7.928	33.963	26.473	91	29.932	0.117	2.133	35.021
1000	1008.1	1	3.742	34.471	27.399	92	44.946	0.035	3.520	120.95

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.493	0.153
5	11	0.494	0.133
10	10	0.504	0.157
20	9	0.448	0.205
30	8	0.378	0.165
40	7	0.742	0.347
60	6	0.200	0.137
80	5	0.039	0.064
100	4	0.012	0.069
150	3	0.007	0.016
200	2	0.001	0.020
1000	1	0.001	0.006

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	11.290	22.894	0
50	11	18.691	37.831	7
30	11	17.688	35.800	12
15	10	12.480	24.742	19
5	9	5.307	11.846	30
1	8	1.014	2.686	45
0.1	7	0.000	0.000	71

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll a: 20.82 mg m-2 day -1      Carbon Fixation: 446.60 mg m-2 day-1  
Phaeophytin: 7.44 mg m-2 day -1      Productivity Index: 21.45 mg C mg Chl M-2 day-1

\* **Abbreviations:** **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll a, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 22, 2009 23:37      **Latitude:** 35.793      **Year:** 2009  
**Station:** 67-80      **Project:** PACOOS      **Longitude:** -124.200      **Day of Year:** 22  
**Cast:** 3      **Platform:** WESTERN FLYER      **Secchi depth (m):** 11

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	1.5	12	13.088	33.020	24.842	88	1.900	0.127	0.545	3.662
5	5.0	11	13.089	33.020	24.841	88	2.015	0.120	0.520	3.174
10	10.5	10	13.069	33.019	24.845	88	2.194	0.105	0.486	3.217
20	20.8	9	12.996	33.020	24.861	88	2.289	0.070	0.548	3.215
30	30.8	8	12.960	33.022	24.869	88	2.464	0.184	0.907	3.541
40	40.8	7	12.065	33.055	25.067	90	6.467	0.194	0.741	5.770
60	60.0	6	10.700	33.215	25.440	91	13.174	0.129	1.098	10.917
80	80.5	5	9.892	33.392	25.716	91	19.084	0.054	1.570	15.691
100	100.6	4	9.391	33.624	25.980	91	23.987	0.082	1.714	22.584
150	149.9	3	8.620	33.924	26.338	91	26.575	0.080	1.844	28.361
200	199.9	2	7.670	33.942	26.494	91	31.630	0.035	2.271	38.919
1000	1009.6	1	3.770	34.462	27.389	92	44.258	0.018	3.442	121.38

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.552	0.196
5	11	0.614	0.191
10	10	0.636	0.201
20	9	0.624	0.225
30	8	0.695	0.280
40	7	0.419	0.200
60	6	0.124	0.095
80	5	0.029	0.045
100	4	0.005	0.027
150	3	0.002	0.014
200	2	0.001	0.014
1000	1	0.003	0.005

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	18.462	33.428	0
50	11	14.246	23.191	6
30	10	22.445	35.296	11
15	10	14.269	22.439	17
5	9	6.668	10.692	27
1	8	2.046	2.943	41
0.1	7	0.000	0.000	74

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll *a*: 26.26 mg m-2 day -1      Carbon Fixation: 465.45 mg m-2 day-1  
Phaeophytin: 9.14 mg m-2 day -1      Productivity Index: 17.73 mg C mg Chl M-2 day-1

\* **Abbreviations:** *DEP* Depth, *PRESS* Pressure, *BTL* Bottle, *TEMP* Temperature, *SAL* Salinity, *TRANSMISS* Transmissivity, *S.I.* Surface Intensity, *CHL* Chlorophyll *a*, *PHAEO* Phaeophytin, *PROD INDEX* Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 23, 2009 03:54      **Latitude:** 35.959      **Year:** 2009  
**Station:** 67-75      **Project:** PACOOS      **Longitude:** -123.845      **Day of Year:** 23  
**Cast:** 4      **Platform:** WESTERN FLYER      **Secchi depth (m):** 12

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	0.3	12	12.143	33.005	25.013	88	5.080	0.244	0.714	5.266
5	5.0	11	12.083	33.005	25.025	88	5.041	0.238	0.833	4.644
10	9.4	10	11.972	33.004	25.045	88	5.350	0.281	0.721	4.872
20	19.8	9	11.827	32.996	25.066	88	5.691	0.257	0.676	5.398
30	29.8	8	11.479	33.048	25.171	87	6.230	0.221	0.770	6.532
40	40.6	7	11.729	33.242	25.276	86	6.070	0.212	0.724	7.591
60	59.7	6	11.736	33.345	25.354	88	7.355	0.323	0.906	8.678
80	80.4	5	11.120	33.306	25.437	91	13.381	0.205	1.156	12.126
100	99.1	4	9.850	33.441	25.761	91	19.424	0.081	1.531	17.094
150	150.5	3	8.754	33.830	26.243	91	26.853	0.058	1.826	27.518
200	200.7	2	8.152	33.976	26.450	91	28.879	0.108	2.061	32.869
1000	1008.2	1	3.798	34.466	27.389	92	43.881	0.044	3.269	119.36

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.598	0.177
5	11	0.568	0.183
10	10	0.751	0.180
20	9	0.921	0.266
30	8	1.146	0.313
40	7	1.315	0.662
60	6	0.977	0.543
80	5	0.175	0.133
100	4	0.053	0.076
150	3	0.002	0.039
200	2	0.002	0.022
1000	1	0.001	0.006

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	31.845	53.223	0
50	11	31.825	56.003	6
30	10	29.076	38.694	11
15	10	17.764	23.641	16
5	9	6.437	6.993	25
1	8	2.238	1.953	36
0.1	7	0.000	0.000	51

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll a: 29.34 mg m-2 day -1      Carbon Fixation: 619.14 mg m-2 day-1  
Phaeophytin: 8.04 mg m-2 day -1      Productivity Index: 21.10 mg C mg Chl M-2 day-1

\* **Abbreviations:** **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll a, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 23, 2009 07:12      **Latitude:** 36.126      **Year:** 2009  
**Station:** 67-70      **Project:** PACOOS      **Longitude:** -123.490      **Day of Year:** 23  
**Cast:** 5      **Platform:** WESTERN FLYER      **Secchi depth (m):** 7

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	0.4	12	11.788	32.991	25.069	84	5.123	0.232	0.731	8.000
5	5.9	11	11.535	33.235	25.305	86	6.686	0.268	0.658	8.998
10	10.0	10	11.646	33.296	25.332	87	7.408	0.389	0.868	9.658
20	19.7	9	11.637	33.392	25.408	89	8.800	0.429	0.924	10.346
30	30.1	8	11.643	33.422	25.431	90	9.062	0.389	1.121	10.623
40	40.1	7	11.480	33.429	25.466	90	10.907	0.504	1.150	11.868
60	59.9	6	10.824	33.389	25.553	91	14.882	0.124	1.405	15.326
80	80.9	5	8.623	33.332	25.872	91	21.891	0.005	1.820	21.929
100	100.4	4	9.504	33.794	26.095	91	25.983	0.054	1.990	26.339
150	149.9	3	9.020	33.967	26.309	91	28.789	0.031	2.234	31.620
200	201.3	2	8.501	34.057	26.461	91	31.312	0.038	2.386	37.651
1000	1006.9	1	3.775	34.448	27.378	92	43.002	0.009	3.343	120.55

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	1.522	0.499
5	11	1.794	0.631
10	10	1.296	0.610
20	9	0.780	0.459
30	8	0.601	0.400
40	7	0.413	0.360
60	6	0.127	0.171
80	5	0.014	0.079
100	4	0.008	0.085
150	3	0.007	0.069
200	2	0.003	0.045
1000	1	0.000	0.008

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	85.570	56.235	0
50	11	71.790	40.016	4
30	11	50.587	28.197	7
15	10	23.203	17.901	11
5	10	8.506	6.562	19
1	9	1.089	1.397	31
0.1	8	0.000	0.000	54

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll *a*: 41.61 mg m-2 day -1      Carbon Fixation: 842.72 mg m-2 day-1  
Phaeophytin: 18.19 mg m-2 day -1      Productivity Index: 20.25 mg C mg Chl M-2 day-1

\* **Abbreviations:** *DEP* Depth, *PRESS* Pressure, *BTL* Bottle, *TEMP* Temperature, *SAL* Salinity, *TRANSMISS* Transmissivity, *S.I.* Surface Intensity, *CHL* Chlorophyll *a*, *PHAEO* Phaeophytin, *PROD INDEX* Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 23, 2009 10:32      **Latitude:** 36.293      **Year:** 2009  
**Station:** 67-65      **Project:** PACOOS      **Longitude:** -123.135      **Day of Year:** 23  
**Cast:** 6      **Platform:** WESTERN FLYER      **Secchi depth (m):** 7

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	1.3	12	12.128	33.226	25.188	86	4.860	0.149	0.890	7.376
5	6.5	11	12.005	33.240	25.221	86	4.502	0.151	0.803	7.056
10	10.5	10	11.680	33.278	25.311	87	7.118	0.339	1.064	8.092
20	21.1	9	11.634	33.327	25.358	89	7.997	0.397	1.116	8.754
30	32.1	8	11.608	33.400	25.420	90	9.039	0.708	1.058	8.860
40	41.3	7	11.314	33.422	25.491	91	12.477	0.354	1.177	12.070
60	61.8	6	10.103	33.486	25.754	91	21.180	0.070	1.677	18.837
80	81.8	5	9.701	33.731	26.012	91	22.163	0.071	1.753	20.458
100	100.9	4	9.450	33.802	26.110	91	26.437	0.047	1.957	25.812
150	152.0	3	8.846	33.978	26.345	91	29.159	0.027	2.117	31.599
200	201.9	2	8.329	34.083	26.507	91	32.543	0.037	2.449	40.013
1000	1007.6	1	4.019	34.441	27.347	92	44.575	0.000	3.356	119.64

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	1.024	0.382
5	11	1.005	0.427
10	10	1.230	0.509
20	9	0.864	0.603
30	8	0.487	0.359
40	7	0.213	0.191
60	6	0.047	0.137
80	5	0.010	0.121
100	4	0.005	0.115
150	3	0.002	0.076
200	2	0.001	0.062
1000	1	0.001	0.011

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	69.195	67.585	0
50	11	47.994	47.753	5
30	11	41.600	41.391	8
15	10	19.746	16.047	13
5	10	7.509	6.103	21
1	9	2.565	2.968	34
0.1	8	4.959	10.192	65

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll a: 37.01 mg m-2 day -1      Carbon Fixation: 757.91 mg m-2 day-1  
Phaeophytin: 16.96 mg m-2 day -1      Productivity Index: 20.48 mg C mg Chl M-2 day-1

\* **Abbreviations:** **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll a, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1



**Cruise:** S109                      **Date GMT:** Jan 23, 2009 13:28                      **Latitude:** 36.459                      **Year:** 2009  
**Station:** 67-60                      **Project:** PACOOS                      **Longitude:** -122.777                      **Day of Year:** 23  
**Cast:** 7                      **Platform:** WESTERN FLYER                      **Secchi depth (m):** 7

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	1.6	12	12.019	33.297	25.263	86	6.150	0.152	0.610	8.516
5	4.9	11	12.017	33.297	25.263	86	6.137	0.141	0.604	8.290
10	9.7	10	12.005	33.297	25.266	86	6.360	0.143	0.671	8.266
20	20.2	9	11.599	33.371	25.399	88	8.495	0.351	0.938	9.268
30	31.4	8	11.597	33.375	25.403	88	9.024	0.371	1.065	9.603
40	40.1	7	11.219	33.377	25.473	90	12.319	0.212	1.122	11.692
60	61.1	6	10.518	33.436	25.644	91	19.045	0.033	1.490	16.577
80	81.4	5	9.571	33.566	25.905	91	22.697	0.027	1.579	21.466
100	101.0	4	9.239	33.851	26.182	91	27.410	0.004	1.939	27.589
150	150.1	3	8.485	33.999	26.417	91	30.432	0.013	2.224	35.241
200	201.2	2	7.874	34.031	26.535	91	31.882	0.018	2.270	40.256
1000	1009.2	1	3.834	34.462	27.383	92	44.213	0.000	3.341	121.43

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.845	0.235
5	11	0.977	0.253
10	10	1.005	0.304
20	9	0.996	0.480
30	8	1.014	0.523
40	7	0.348	0.274
60	6	0.092	0.201
80	5	0.023	0.216
100	4	0.001	0.097
150	3	0.001	0.053
200	2	0.001	0.044
1000	1	0.002	0.004

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	81.380	96.267	0
50	11	65.972	67.535	5
30	11	40.704	41.668	9
15	10	17.394	17.307	14
5	10	6.763	6.729	22
1	9	1.462	1.468	34
0.1	8	0.241	0.237	57

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll a: 33.07 mg m-2 day -1                      Carbon Fixation: 886.51 mg m-2 day-1  
Phaeophytin: 10.61 mg m-2 day -1                      Productivity Index: 26.81 mg C mg Chl M-2 day-1

\* **Abbreviations:** **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll a, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109                      **Date GMT:** Jan 23, 2009 17:04                      **Latitude:** 36.627                      **Year:** 2009  
**Station:** 67-55                      **Project:** PACOOS                      **Longitude:** -122.419                      **Day of Year:** 23  
**Cast:** 8                      **Platform:** WESTERN FLYER                      **Secchi depth (m):** 7

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	1.0	12	12.359	33.407	25.284	88	6.294	0.199	0.652	7.896
5	4.4	11	12.359	33.406	25.283	88	6.060	0.180	0.644	7.450
10	9.9	10	12.312	33.417	25.301	88	6.737	0.238	0.900	7.751
20	21.7	9	11.828	33.417	25.393	89	9.108	0.472	0.995	9.154
30	30.9	8	11.748	33.449	25.433	89	10.294	0.423	1.003	9.931
40	41.1	7	11.569	33.478	25.488	90	12.515	0.281	1.336	11.481
60	62.1	6	10.399	33.646	25.828	91	21.920	0.037	1.832	19.708
80	82.0	5	9.867	33.785	26.027	91	24.880	0.047	1.917	23.846
100	101.9	4	9.336	33.858	26.172	91	26.551	0.003	2.121	26.405
150	151.9	3	8.595	33.958	26.368	91	29.031	0.024	2.098	31.610
200	203.5	2	8.465	34.096	26.497	91	32.053	0.032	2.411	38.250
1000	1008.8	1	3.870	34.445	27.365	92	44.068	0.019	3.353	118.38

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.751	0.312
5	11	0.751	0.312
10	10	0.780	0.301
20	9	0.780	0.450
30	8	0.592	0.445
40	7	0.347	0.348
60	6	0.067	0.182
80	5	0.029	0.147
100	4	0.011	0.133
150	3	0.001	0.070
200	2	0.008	0.072
1000	1	0.001	0.001

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	51.095	67.998	0
50	11	44.338	59.005	6
30	11	29.315	39.012	10
15	10	12.948	16.608	15
5	10	4.550	5.836	24
1	9	1.345	1.725	37
0.1	8	0.195	0.330	63

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll a: 28.50 mg m-2 day -1                      Carbon Fixation: 645.45 mg m-2 day-1  
 Phaeophytin: 12.27 mg m-2 day -1                      Productivity Index: 22.65 mg C mg Chl M-2 day-1

\* **Abbreviations:** **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll a, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 23, 2009 20:07      **Latitude:** 36.735      **Year:** 2009  
**Station:** H3      **Project:** PACOOS      **Longitude:** -122.020      **Day of Year:** 23  
**Cast:** 9      **Platform:** WESTERN FLYER      **Secchi depth (m):** 7

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
0	2.7	12	12.207	33.385	25.296	89	6.255	0.312	0.807	8.381
5	5.6	11	12.235	33.363	25.273	89	6.596	0.537	0.747	8.097
10	9.7	10	12.210	33.392	25.301	89	6.467	0.358	0.760	7.674
20	19.7	9	12.108	33.485	25.392	89	7.200	0.342	0.688	7.887
30	30.7	8	11.894	33.515	25.456	89	8.404	0.396	0.857	8.394
40	40.1	7	11.747	33.535	25.500	89	10.113	0.467	1.087	10.230
60	61.8	6	11.542	33.559	25.557	89	11.666	0.457	1.276	11.825
80	81.1	5	10.880	33.597	25.706	90	18.578	0.203	1.428	16.781
100	100.7	4	10.638	33.695	25.826	90	20.976	0.241	1.793	20.765
150	150.4	3	9.748	33.801	26.060	91	24.200	0.178	2.095	23.255
200	202.6	2	9.007	34.022	26.355	91	29.313	0.210	2.366	32.935
1000	1009.1	1	3.930	34.442	27.357	89	43.379	0.108	3.472	120.76

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
0	12	0.690	0.149
5	11	0.612	0.133
10	10	0.714	0.165
20	9	0.742	0.233
30	8	0.855	0.393
40	7	0.723	0.349
60	6	0.601	0.330
80	5	0.181	0.273
100	4	0.148	0.211
150	3	0.023	0.136
200	2	0.010	0.090
1000	1	0.007	0.054

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
100	12	46.872	67.894	0
50	11	36.757	60.019	6
30	11	23.650	38.618	11
15	10	13.353	18.705	17
5	10	5.036	7.054	26
1	9	1.202	1.620	38
0.1	8	0.515	0.603	57

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll a: 26.34 mg m-2 day -1      Carbon Fixation: 632.59 mg m-2 day-1  
Phaeophytin: 6.34 mg m-2 day -1      Productivity Index: 24.01 mg C mg Chl M-2 day-1

\* **Abbreviations:** **DEP** Depth, **PRESS** Pressure, **BTL** Bottle, **TEMP** Temperature, **SAL** Salinity, **TRANSMISS** Transmissivity, **S.I.** Surface Intensity, **CHL** Chlorophyll a, **PHAEO** Phaeophytin, **PROD INDEX** Productivity Index mg C/mg Chl m-3 day-1

**Cruise:** S109      **Date GMT:** Jan 23, 2009 22:51      **Latitude:** 36.795      **Year:** 2009  
**Station:** C1      **Project:** PACOOS      **Longitude:** -121.846      **Day of Year:** 23  
**Cast:** 10      **Platform:** WESTERN FLYER      **Secchi depth (m):** 7

\* Note: Latitude and Longitude are reported in decimal degrees. '---' signifies no data.

**PHYSICAL AND CHEMICAL**

DEP (m)	PRESS (db)	BTL #	TEMP (°C)	SAL	SIGMA T (kg l-1)	TRANSMISS (%)	NO3 (µM)	NO2 (µM)	PO4 (µM)	SIO4 (µM)
5	5.1	11	12.089	33.465	25.381	87	8.728	0.318	0.841	10.141
10	10.6	10	12.038	33.518	25.432	88	8.924	0.322	0.871	10.310
20	21.0	9	11.870	33.547	25.485	89	9.981	0.338	1.031	11.255
30	31.1	8	11.805	33.549	25.500	89	8.393	0.292	1.022	9.038
40	40.3	7	11.653	33.564	25.540	90	10.291	0.365	1.025	10.649
60	61.0	6	11.573	33.570	25.560	90	11.171	0.424	1.193	11.719
80	81.1	5	11.529	33.579	25.575	89	12.635	0.457	1.232	13.572
100	101.2	4	11.472	33.587	25.593	86	12.813	0.407	1.169	14.536
150	151.3	3	11.351	33.600	25.626	85	13.804	0.442	1.215	15.287
200	203.4	2	9.961	33.785	26.014	76	20.431	0.292	1.891	26.365
250	253.5	1	8.617	33.973	26.378	79	28.729	0.192	2.483	41.327

**CHLOROPHYLL**

DEP (m)	BTL #	CHL (mg m-3)	PHAEO (mg m-3)
5	11	0.892	0.276
10	10	0.761	0.320
20	9	0.676	0.299
30	8	0.648	0.318
40	7	0.611	0.312
60	6	0.493	0.320
80	5	0.535	0.378
100	4	0.564	0.526
150	3	0.526	0.476
200	2	0.451	0.691

**PRIMARY PRODUCTION**

*Samples are taken by light level.*

LIGHT LEVEL % S. I.	BTL #	PRIMARY PRODUCTION (mg m-3 d-1)	PROD INDEX carbon/chl (mg m-3 d-1)	LIGHT DEPTH (m)
50	11	33.343	37.367	4
30	11	27.506	30.825	8
15	10	13.478	17.715	14
5	10	5.001	6.573	23
1	9	2.151	3.180	36
0.1	8	0.343	0.529	56

**INTEGRATED VALUES**

*Values are integrated from surface to 1.0% of light penetrating depth.*

Chlorophyll *a*: 30.64 mg m-2 day -1      Carbon Fixation: 555.82 mg m-2 day-1  
Phaeophytin: 12.19 mg m-2 day -1      Productivity Index: 18.14 mg C mg Chl M-2 day-1

\* **Abbreviations:** *DEP* Depth, *PRESS* Pressure, *BTL* Bottle, *TEMP* Temperature, *SAL* Salinity, *TRANSMISS* Transmissivity, *S.I.* Surface Intensity, *CHL* Chlorophyll *a*, *PHAEO* Phaeophytin, *PROD INDEX* Productivity Index mg C/mg Chl m-3 day-1

**Table A4:** *Marine mammal observations.* This table lists the results of the marine mammal observations made during the PaCOOS cruise of January 2009. The data are listed alphabetically by species' scientific name, then chronologically within each species.

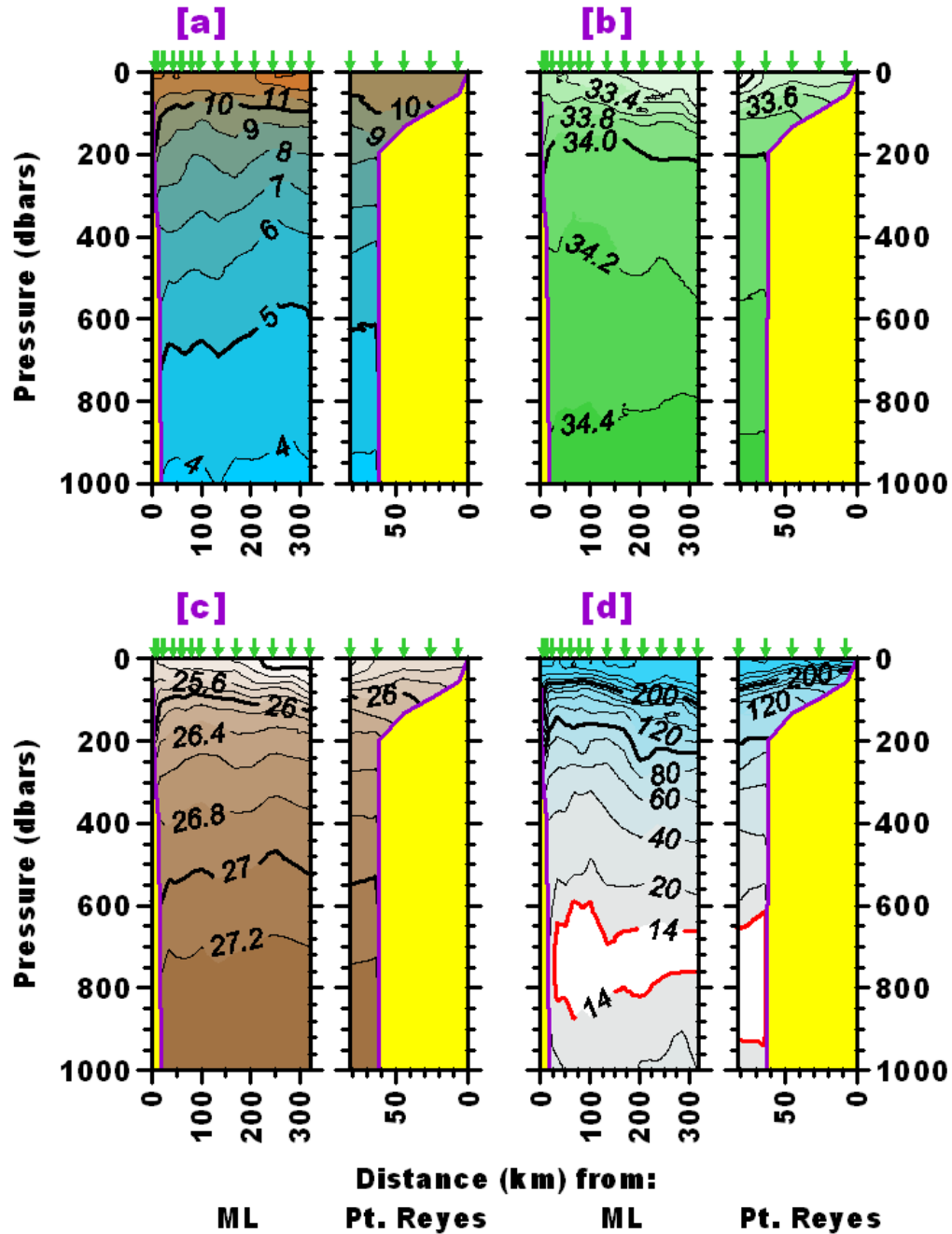
Species Code	Scientific Name	Group Size	Sighting Number	Date (m/dd/yyyy)	North Latitude (dd mm.mmm)	West Longitude (ddd mm.mmm)
69	<i>Eschrichtius robustus</i>	1	1	1/20/2009	36° 48.540	121° 47.640
69	<i>Eschrichtius robustus</i>	1	2	1/20/2009	36° 47.820	121° 54.600
69	<i>Eschrichtius robustus</i>	1	3	1/20/2009	36° 46.920	121° 57.540
69	<i>Eschrichtius robustus</i>	6	4	1/20/2009	36° 43.380	122° 05.700
69	<i>Eschrichtius robustus</i>	2	5	1/20/2009	36° 46.740	122° 05.100
69	<i>Eschrichtius robustus</i>	4	6	1/20/2009	36° 48.060	122° 08.640
69	<i>Eschrichtius robustus</i>	6	7	1/20/2009	36° 45.240	122° 05.880
69	<i>Eschrichtius robustus</i>	4	8	1/20/2009	36° 47.040	122° 06.420
69	<i>Eschrichtius robustus</i>	5	9	1/20/2009	36° 45.240	122° 09.480
69	<i>Eschrichtius robustus</i>	7	10	1/20/2009	36° 46.200	122° 08.220
69	<i>Eschrichtius robustus</i>	3	12	1/20/2009	36° 46.080	122° 09.360
69	<i>Eschrichtius robustus</i>	2	13	1/20/2009	36° 45.540	122° 52.800
22	<i>Lagenorhynchus obliquidens</i>	15	11	1/20/2009	36° 45.660	122° 10.260
22	<i>Lagenorhynchus obliquidens</i>	40	27	1/22/2009	36° 09.600	123° 26.280
27	<i>Lissodelphis borealis</i>	260	27	1/22/2009	36° 09.600	123° 26.280
76	<i>Megaptera novaeangliae</i>	1	14	1/20/2009	36° 38.640	122° 47.400
76	<i>Megaptera novaeangliae</i>	1	15	1/20/2009	36° 38.940	122° 54.480
44	<i>Phocoenoides dalli</i>	5	18	1/21/2009	35° 36.360	125° 01.860
44	<i>Phocoenoides dalli</i>	13	20	1/22/2009	35° 47.940	124° 06.420
44	<i>Phocoenoides dalli</i>	7	25	1/22/2009	35° 58.740	123° 51.720
44	<i>Phocoenoides dalli</i>	3	26	1/22/2009	36° 02.940	123° 40.740
46	<i>Physeter macrocephalus</i>	8	21	1/22/2009	35° 52.140	124° 02.460

Species Code	Scientific Name	Group Size	Sighting Number	Date (m/dd/yyyy)	North Latitude (dd mm.mmm)	West Longitude (ddd mm.mmm)
<b>PINNIPEDS and SOUTHERN SEA OTTERS</b>						
CU	<i>Callorhinus ursinus</i>	2	16	1/20/2009	36° 40.260	123° 03.540
CU	<i>Callorhinus ursinus</i>	1	17	1/20/2009	36° 24.360	123° 39.840
CU	<i>Callorhinus ursinus</i>	1	19	1/21/2009	35° 38.400	125° 09.840
CU	<i>Callorhinus ursinus</i>	1	22	1/22/2009	34° 53.700	123° 58.260
CU	<i>Callorhinus ursinus</i>	1	23	1/22/2009	35° 06.180	123° 50.700
CU	<i>Callorhinus ursinus</i>	2	24	1/22/2009	35° 58.500	123° 50.520
EL	<i>Enhydra lutris</i>	64	1b	1/20/2009	36° 48.540	121° 47.220
EL	<i>Enhydra lutris</i>	48	29a	1/23/2009	36° 48.480	121° 47.280
MA	<i>Mirounga angustirostris</i>	1	28	1/23/2009	36° 47.820	121° 51.720
		1	29	1/23/2009	36° 48.480	121° 47.280
PV	<i>Phoca vitulina</i>	6	1a	1/20/2009	36° 48.540	121° 47.220
		1	29b	1/23/2009	36° 48.480	121° 47.280

**Table A5:** *Summary of marine mammal observations.* This table summarizes the results of the marine mammal observations made during the PaCOOS cruise of January 2009. The data are listed alphabetically by species' scientific name.

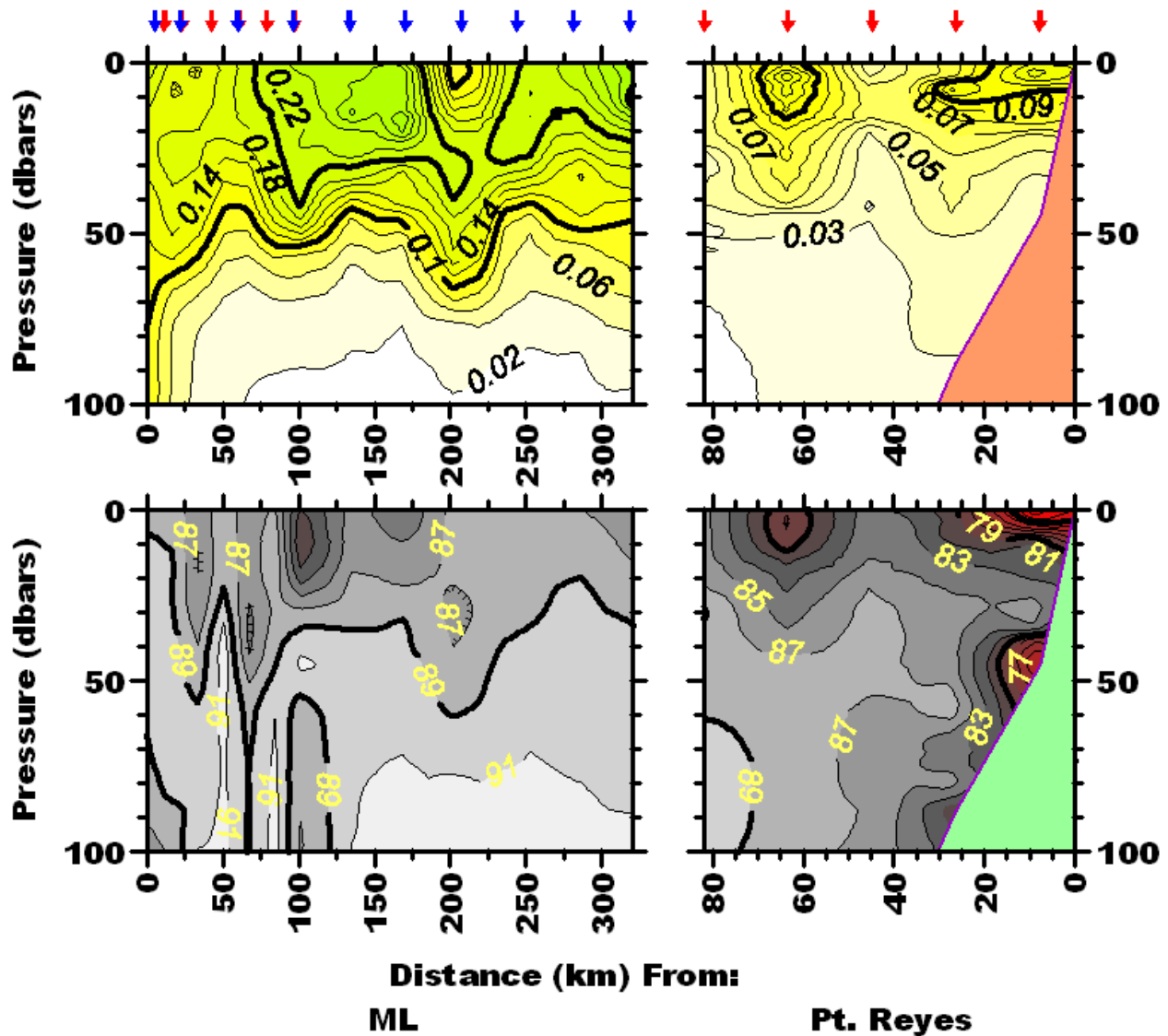
<b>Species Code</b>	<b>Scientific Name</b>	<b>Total sightings</b>	<b>Total animals</b>
69	<i>Eschrichtius robustus</i>	12	42
22	<i>Lagenorhynchus obliquidens</i>	2	55
27	<i>Lissodelphis borealis</i>	1	260
76	<i>Megaptera novaeangliae</i>	2	2
44	<i>Phocoenoides dalli</i>	4	28
46	<i>Physeter macrocephalus</i>	1	8
<b>Total number of cetaceans</b>			<b><u>395</u></b>

Appendix B

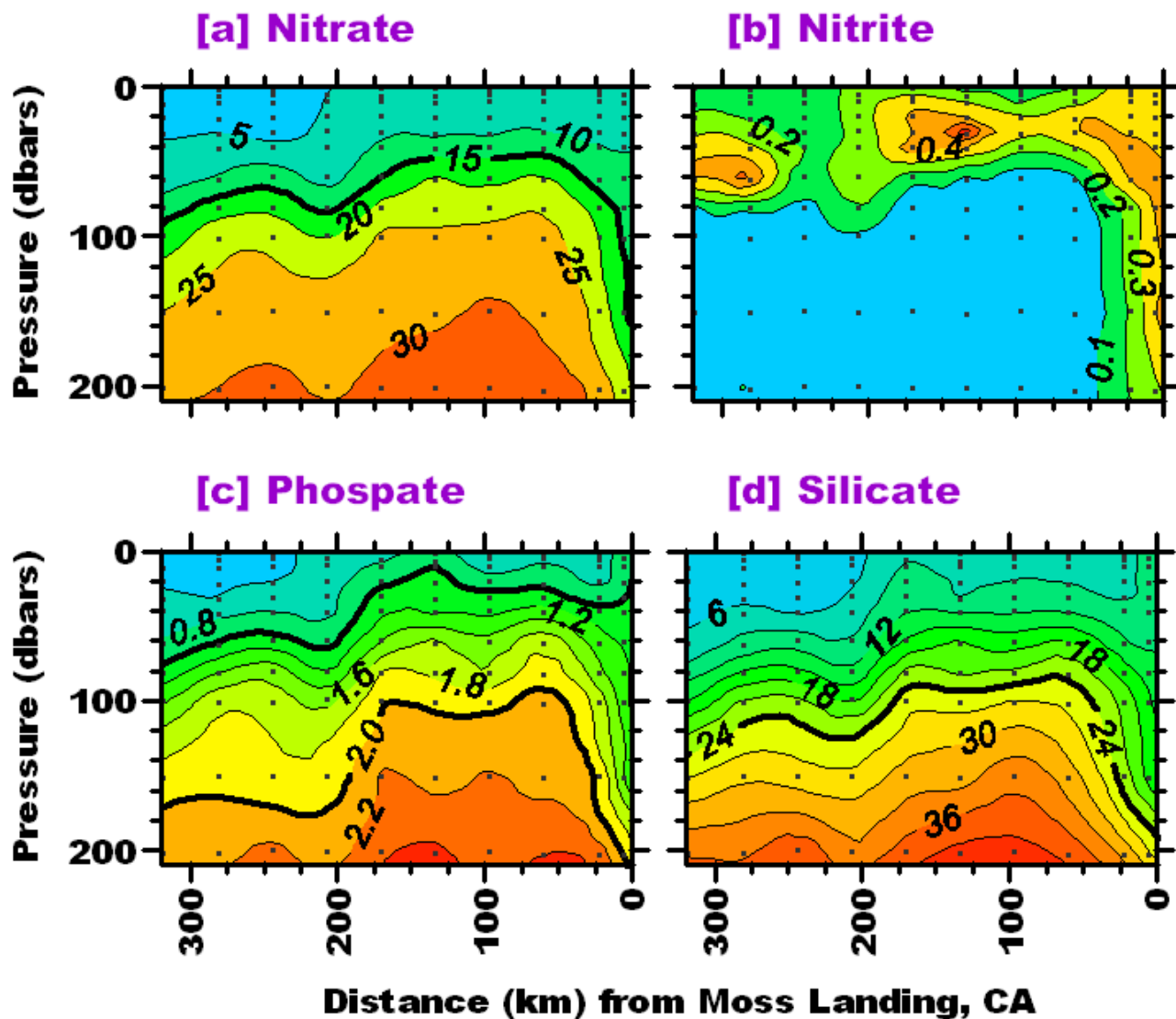


**Figure 7:** Contours of (a) temperature ( $^{\circ}\text{C}$ ), (b) salinity, (c) density anomaly ( $\text{kg m}^{-3}$ ), and (d) oxygen ( $\mu\text{mol kg}^{-1}$ ) fields along the lines of hydrographic stations from Moss Landing, California (on the left) to CalCOFI 67-90, and from Drake's Bay, California (on the right) to CalCOFI 60-60. Arrows along the top axes indicate the locations of the hydrographic stations; the gap between diagram sections marks the break between CalCOFI lines 67 and 60. Contour intervals for panels a-d are  $1^{\circ}\text{C}$ ,  $0.2$ ,  $0.2 \text{ kg m}^{-3}$ , and  $20 \mu\text{mol kg}^{-1}$ , respectively, except that the (nearly) oxygen minimum contour of  $14 \mu\text{mol kg}^{-1}$  is highlighted in red in panel d.

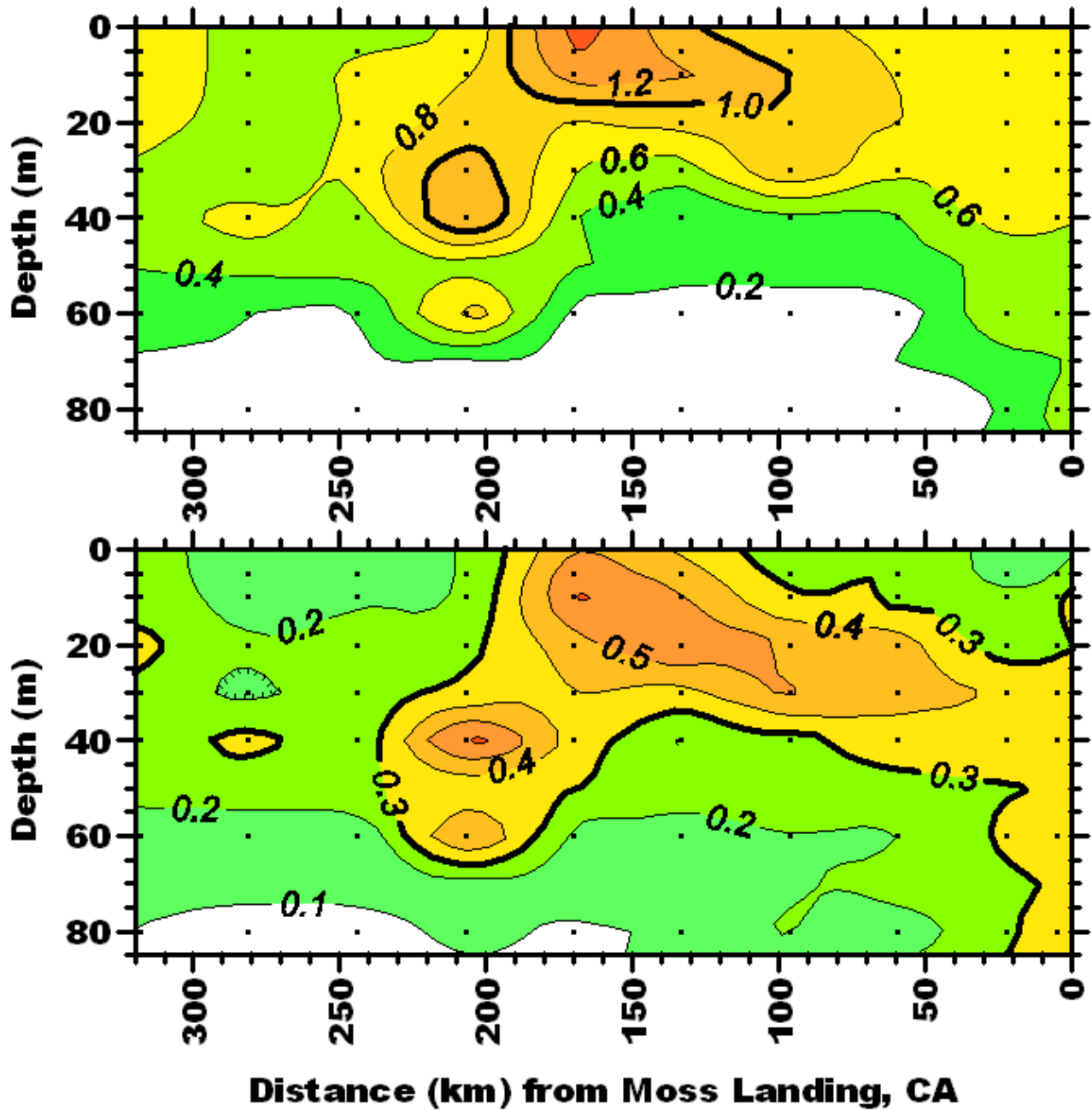




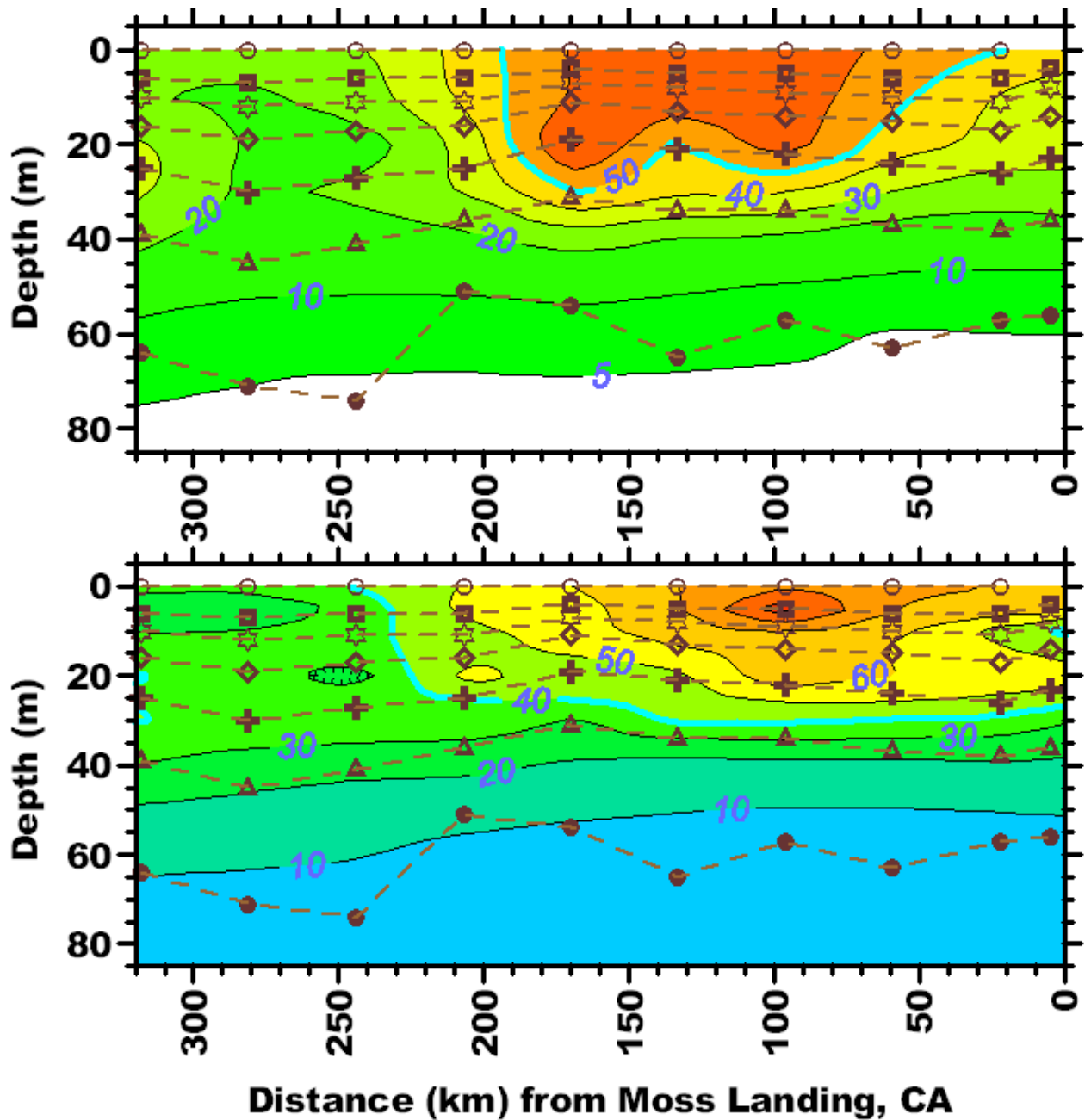
**Figure 8:** Contours of fluorescence (volts) [upper panel] and transmissivity (percentage) [lower panel] in the upper 100 dbars of the water column along the lines of hydrographic stations from Moss Landing, California (on the left) to CalCOFI 67-90, and from Drake's Bay, California (on the right) to CalCOFI 60-60. Blue (red) arrows along the upper axis of the upper panel indicate the locations of the PaCOOS (NPS) cruise hydrographic stations; the gap between diagram sections marks the break between CalCOFI lines 67 and 60. The contour intervals are 0.02 volts, 0.01 volts, and 2 percent, respectively, for the upper left, upper right, and lower panels. (Different fluorometers were used on the PaCOOS and NPS cruises, necessitating both that different contour intervals be used for each section of the upper panel and that data from only the PaCOOS [NPS] cruise be used for the upper left [right] panel of the diagram.) 0.10 and 0.20 volts (upper), while 69, 79, and 89 percent (lower), contours are highlighted.



**Figure 9:** Contours of (a) nitrate ( $\mu\text{M}$ ), (b) nitrite ( $\mu\text{M}$ ), (c) phosphate ( $\mu\text{M}$ ), and (d) silicate ( $\mu\text{M}$ ) fields along the line of hydrographic stations from Moss Landing, California (on the right) to CalCOFI 67-90. The dots indicate the water sample locations. Contour intervals for panels a-d are  $5\mu\text{M}$ ,  $0.1\mu\text{M}$ ,  $0.2\mu\text{M}$ , and  $3\mu\text{M}$ , respectively.



**Figure 10:** Contours of chlorophyll-*a* ( $\text{mg m}^{-3}$ ) [upper panel] and phaeophytin ( $\text{mg m}^{-3}$ ) [lower panel] in the upper 85 m of the water column along the line of hydrographic stations from Moss Landing, California (on the right) to CalCOFI 67-90. Dots indicate the water sample locations. The contour intervals are 0.2 and 0.1  $\text{mg m}^{-3}$ , respectively, for the upper and lower panels. 1.0 (upper panel) and 0.3 (lower panel)  $\text{mg m}^{-3}$  contours are highlighted.



**Figure 11:** Contours of primary production ( $\text{mg Carbon m}^{-3} \text{ day}^{-1}$ ) [upper panel] and productivity index (ratio of  $\text{mg Carbon}$  to  $\text{mg Chlorophyll-a m}^{-3} \text{ day}^{-1}$ ) [lower panel] in the upper 85 m of the water column along the line of hydrographic stations from Moss Landing, California (on the right) to CalCOFI 67-90. Samples are taken by the percentage of the surface light intensity level (light penetration depth). (Light penetration) depths of those light intensity levels are shown by the various symbols, with like symbols connected by dashed lines. (100% = open circles, 50% = open squares, 30% = open stars, 15% = open diamonds, 5% = plusses, 1% = open triangles, 0.1% = filled circles.) The contour intervals are  $10 \text{ mg Carbon m}^{-3} \text{ day}^{-1}$  for both panels, except that the  $5 \text{ mg Carbon m}^{-3} \text{ day}^{-1}$  contour is also shown in the upper panel. 50 (upper panel) and 40 (lower panel)  $\text{mg Carbon m}^{-3} \text{ day}^{-1}$  contours are highlighted.

## Appendix C

The following is the introduction from the manual for the Seatech transmissometers that were mounted on the CTD during the PaCOOS and NPS cruises of January (and February) 2009.

The Sea Tech 25 cm pathlength transmissometer has been designed to provide accurate in situ measurements of beam transmission and the concentration of suspended matter in relatively clear waters.

The two basic processes that alter the underwater distribution of light are absorption and scattering. Absorption is a change of light energy into other forms of energy whereas scattering entails a change in direction of the light without loss of energy.

In a pure absorbing medium, the loss of light due to absorption in a well-collimated beam of monochromatic light will be given by  $I(z) = I(0)e^{-az}$ , where "a" is the absorption coefficient with units of  $m^{-1}$ . Similarly, in a pure scattering medium, the light redirected from a well-collimated beam of monochromatic light will be given by  $I(z) = I(0)e^{-bz}$ , where "b" is the volume scattering coefficient with units of  $m^{-1}$ . Since attenuation is defined as the sum of absorption and scattering, we get  $a + b = c$ , where "c" is the beam attenuation coefficient.

The light lost from a well-collimated monochromatic beam of light in a scattering and absorbing medium is thus given by  $I(z) = I(0)e^{-cz}$ . This can be rewritten as  $T(z) = I(z)/I(0) = e^{-cz}$ , where  $T(z)$  is the percent light transmitted over a distance, "z". It should be noted that transmission is always over a given distance, whereas the beam attenuation coefficient, "c", is independent of distance. "c" is computed by  $-\ln(T)/z$ , where z is the pathlength of the instrument.

The simple exponential relationship holds only if the light is monochromatic. The Sea Tech transmissometer employs a light emitting diode (LED) light source with a wavelength of 660 nm, which is in the red part of the spectrum. This LED is nearly monochromatic.

A beam attenuation coefficient, "c", can be divided into three parts: 1) That due to water,  $c_w$ ; 2) that due to suspended particulate matter,  $c_p$ ; and 3) that due to dissolved materials (mostly humic acids or "yellow matter"),  $c_y$ . Hence,  $c = c_w + c_p + c_y$ . Each of these components has distinct spectral characteristics. Yellow matter absorbs strongly in the blue part of the spectrum. This absorption decreases exponentially with increasing wavelengths. The beam attenuation coefficient for particulate matter is much less wavelength dependent. It varies approximately as  $\lambda^{-1}$ . The attenuation spectrum of natural waters is a composite of the three components, depending on the relative concentrations. The yellow matter is a by-product of organic decay and can be present in large amounts in lakes, reservoirs, and near-shore waters. At 660 nm, the attenuation of yellow matter is negligible, however, so that the attenuation is due to particulate matter and sea water only.

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18.	Paul Choboter CalPoly State University San Luis Obispo, CA	1
19.	Roger Hewitt NOAA La Jolla, CA	1
20.	Carmen G. Castro Consejo Superior de Investigaciones Científicas Spain	1
21.	Newell Garfield San Francisco State University San Francisco, CA	1
22.	Francisco Chavez Monterey Bay Aquarium Research Institute Moss Landing, CA	1
23.	Tim Pennington Monterey Bay Aquarium Research Institute Moss Landing, CA	1
24.	Jeff Paduan Naval Postgraduate School Monterey, CA	1
25.	Ben Jokinen Moss Landing Marine Labs Moss Landing, CA	1

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