Cordell Bank Ocean Monitoring Project (CBOMP)

Goals, Methodology, and 2004 Results

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Summary

Cordell Bank is a rocky underwater ridge located 37 km off the Point Reyes Peninsula, in the heart of the Cordell Bank National Marine Sanctuary (CBNMS). Strong upwelling plumes along with the southbound California Current interact with the bank to create one of the most biologically productive areas off the California coast. In January 2004 the CBNMS initiated the Cordell Bank Ocean Monitoring Program (CBOMP) to gather baseline data on the vertebrate and planktonic ecology and how species assemblages interact with physical oceanographic parameters on both a spatial and a temporal basis. CBOMP is part of a larger effort to integrate the Pacific national marine sanctuaries with regional and national Integrated Ocean Observing Systems. This report summarizes the establishment of the CBOMP, details survey-design and data-collection methodology, and briefly presents observation results from 2004.

Weather and ocean conditions permitting, single-day monitoring cruises over Cordell Bank are conducted approximately once per month. The survey pattern consists of eight transects of 12.96 km each, located 2.56 km apart, and covering a trapezoidal survey area of 12.9 X 21.2 km. Data on the distribution of marine birds, mammals, and pelagic fish are collected by trained observers employing standard strip-survey methodology of varying strip width, depending on the taxa being censused. For all taxa, observations are binned into 100-m strips in order to better analyze detection capabilities and for comparison with other surveys. For whales and smaller cetaceans, line-transect methodology is also employed. Boats along with type, activity (e.g., fishing, transiting), and direction of travel; balloons and other flotsam; jellyfish; Velella; and kelp observed within varying distances of the survey vessel are also recorded or scored.

Krill and other zooplankton abundance is estimated with a Simrad EK60 echosounder with a single 120Khz split-beam transducer mounted on a boom arm over the starboard side of the vessel. Data are collected with the intent of identifying both three-dimensional spatial location and area-backscatter of krill. Sporadic net-sampling is planned for ground-truthing and calibration to develop a protocol for translating echosounder data into krill abundance and other invertebrates or fish prey. Weather

observations are recorded at the start of each transect. A continuously logging surface thermo-salinograph (TSG) records location, salinity and water temperature along the entire cruise line. In addition, CTD casts are performed at 7 locations during each cruise. Four data channels are used to record pressure, temperature, conductivity, flourometry and light levels.

We will also capture and include data from weather and ocean conditions collected at NOAA buoys; sea surface temperature derived from the Advanced Very High Resolution Radiometer; chlorophyll *a* concentrations from monthly composites of Seaviewing Wide Field-of-view Sensor imagery; and upwelling and other global climactic indices (SOI, NOI, PDO, NAO, etc.) provided by NOAA/NWS and other sources. Data will be used to construct GIS maps relating oceanography (e.g., fronts, temperature, density, and upwelling) with krill distribution and bird and mammal distribution on a seasonal and annual basis.

This program will continue in the form of long term monitoring to assess and evaluate trends in the distribution and abundance of marine birds and mammals relative to long-term changes in ocean conditions, seasons, biological productivity, and human use patterns. To investigate how observed patterns on Cordell Bank relate to broader spatial patterns, data from this program will be integrated with that of other similar programs along the Pacific North American coast, to investigate these factors at broader spatial scales. Finally, data will be accessible for use by HAZMAT and other teams during an oil spill or other event necessitating immediate response, in as close to real time as possible. A complete metadata has been developed for this database and is available through the Cordell Bank NMS.

During 2004 we completed 51 transects during eight survey dates. A total of 621.5 km of transects were surveyed during 1,976 one-minute blocks, and representing a total survey area of 124.3 sq km for birds, approximately 215 sq km for pinnipeds and small cetaceans, and approximately 500 sq km for large cetaceans during. A total of 12,266 vertebrates of 57 taxa were recorded during surveys. These included 11,594 seabirds of 40 taxa , 503 marine mammals of 13 taxa, and 169 pelagic fish of 3 taxa. Median Sea Surface Temperatures ranged from 11.96° C in March to 14.98° C in October, with temperature variation within each cruise varying from x (SD) in November to x in October. We anticipate that greater variation in SST will reflect greater ocean mixing, increased frontal activity, and/or an infusion of warmer offshore water. During September through December, CTD casts showed stratified and un-stratified profiles, which appeared to reflect wind conditions.

Introduction

Cordell Bank National Marine Sanctuary (CBNMS) was established in 1989 to protect the bank and surrounding ecosystem. Cordell Bank is a rocky underwater ridge, the center of which is approximately 85 km northwest of San Francisco and 37 km west of the Point Reyes Lighthouse in Marin County, California (Fig. 1). The elliptical shaped base is approximately 14 km by 7 km at its 50-fathom isobath, and it rises to within 37 m of the ocean's surface. To the west of the bank the continental shelf drops off to a depth of 3000 m, and the Bodega Canyon, located to the north, extends south-eastward (Figure 2). Strong upwelling plumes that originate off Point Arena and Point Reyes, along with the southbound California Current, interact with the bank to draw nutrients to the surface, helping to create one of the most biologically productive areas off the California coast.

Figure 1. Position of Cordell Bank relative to the California Coast and San Francisco.

Beginning in November 2001, the National Marine Sanctuary Program initiated a Joint Management Plan Review (JMPR) for the three central California National Marine Sanctuaries: Cordell Bank, Gulf of the Farallones, and Monterey Bay. Sanctuary Advisory Councils attended a series of scoping meetings to identify, prioritize, and evaluate current and emerging issues. During this process a better understanding of the function of the pelagic ecosystem was identified as a priority goal for the sanctuaries. One of the site-specific issues identified by the CBNMS Advisory Council was to develop a coordinated and integrated, long-term monitoring program.

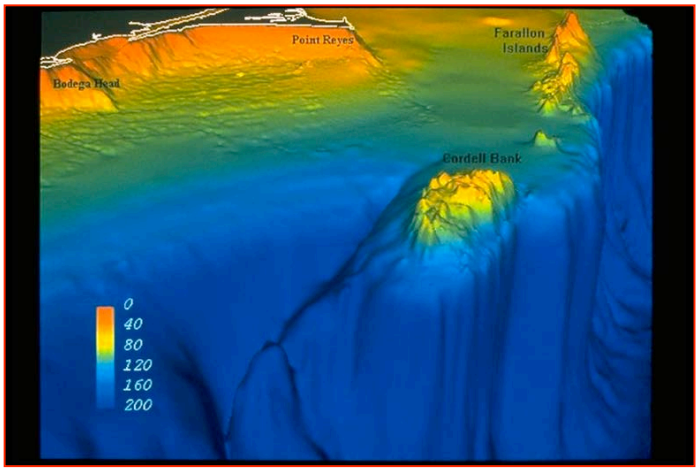


Figure 2. Cordell Bank showing surrounding seafloor along the edge of the continental shelf, Bodega Canyon to the north and east of the Bank, and other exaggerated geographic relief.

In order to best protect the biological resources of Cordell Bank, additional information was needed on the ecology of both resident and migratory species that use associated waters, and how these species interact with each other, the planktonic environment, and physical oceanographic parameters that characterize these waters. To address this need, the CBNMS initiated the

Cordell Bank Ocean Monitoring Program (CBOMP) in January 2004. CBOMP is part of a larger effort to integrate the Pacific national marine sanctuaries with regional and national Integrated Ocean Observing Systems. CBOMP will be compatible with and compliment the *Wind to Whales* program operated by the University of California at Santa Cruz in the Monterey Bay National Marine Sanctuary (MBNMS), and to a similar program that is being developed for the Gulf of the Farallones National Marine Sanctuary. The data structure will also be constructed to capture information from other sources such as NOAA and SEA Station buoys and satellites, upwelling and other global climactic indices (Southern and Northern Oscillation Indices, Pacific Decadal Oscillation, etc.), beach monitoring programs, and data sets developed by other partnering agencies. Eventually the project will provide physical and biological data to the Central and Northern California Ocean Observing System, and be available for exchange and interpretation on the MBNMS/SIMoN web site.

This report summarizes the establishment of the Cordell Bank Ocean Monitoring Project, details survey-design and data-collection methodology, and presents observation results from 2004.

Program Goals

The primary goals of the CBOMP are 1) to characterize the planktonic and vertebrate fauna in waters over Cordell Bank and 2) to document variation in the temporal and spatial occurrence patterns and relative abundance of these fauna to variation in the proximate oceanic environment.

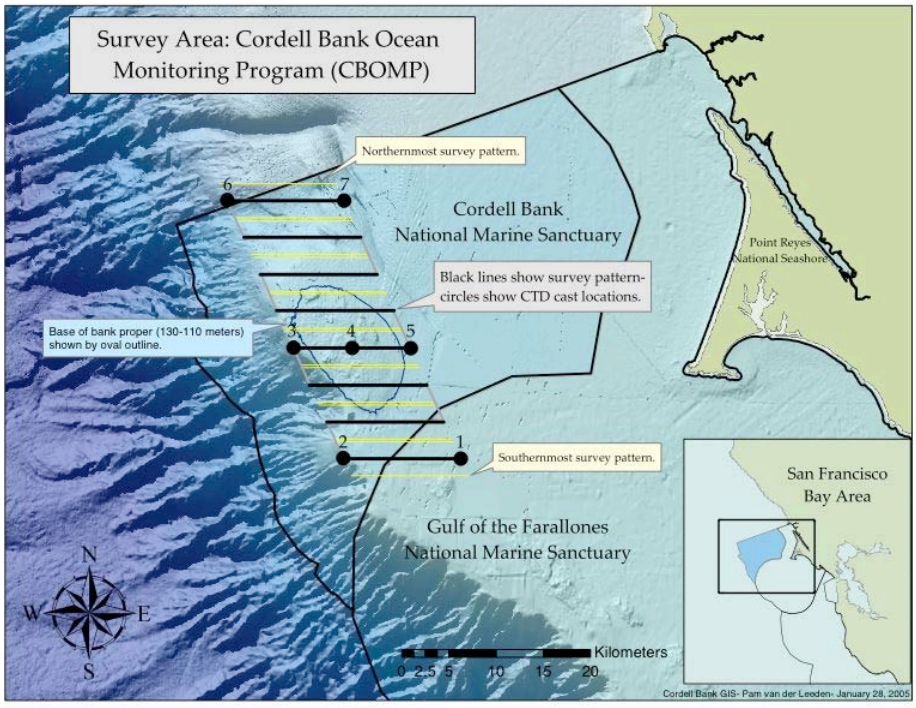


Figure 3. Cordell Bank Ocean Monitoring Program survey pattern relative to Cordell Bank, showing area covered by 13 survey patterns and positions of seven CTD casts (solid black circles).

Weather and ocean conditions permitting, single-day monitoring cruises, covering eight east-to-west transects over Cordell Bank (Fig. 3), are conducted approximately once per month. Data on the distribution of marine birds, mammals, and other macro-vertebrates are collected by trained observers; krill and other zooplankton abundance are estimated with a Simrad EK60 echo sounder; and physical oceanographic parameters, including temperature, salinity, and thermocline depth, are collected with a continuously logging Seacat-SBE-45 thermo-salinograph along with a series of CTD casts recording depth profiles of temperature, salinity, light penetration, and chlorophyll. Data will be used to construct GIS maps relating oceanography (e.g., fronts, temperature, thermocline, density, and upwelling) with krill distribution and bird and mammal distribution on a seasonal and annual basis.

This program will continue in the form of long term ocean-observation monitoring to assess and evaluate trends in the distribution and abundance of marine birds and mammals relative to long-term changes in ocean conditions, seasons, biological productivity, and human use patterns. To investigate how observed patterns on Cordell Bank relate to broader spatial patterns, data from this program will be integrated with that of other similar programs along the Pacific North American coast, to investigate these factors at broader spatial scales. Finally, data will be accessible for use by Office of Hazardous Materials Safety (HAZMAT) and other teams during an oil spill or other event necessitating immediate response, in as close to real time as possible.

Detailed Methodology

Survey Vessel

The CBNMS 35-foot research vessel *C. magister* (Fig. 4), docked at Spud Point Marina, Bodega Bay, has been designed to perform the surveys. The vessel has a survey speed of 10 kts and a top speed of 20 kts. A 3-kw true sinewave inverter powers all shipboard electronics. The boat's position, speed and heading are logged continuously on two laptops simultaneously. Accuracy of heading and position is maintained by a WASS enabled GPS and Robertson's fluxgate compass tied into a Nobeltec Visual Navigation Suite. A Seabird SBE-19 CTD is deployed using a davit and lowered via a Kolstan oceanographic winch with 3/16th conducting cable. An observation deck with three elevated chairs and a surrounding tarpaulin to screen the weather has been constructed above the cabin. The observation height of a person sitting in the observation chairs is approximately 3.8 m above sea level.

Figure 4. Research vessel* C. magister*, Spud Point Marina, Bodega Bay.

Survey Area and Logistics

Given logistical constraints, the survey area (Fig. 3) was designed to cover as much of the waters surrounding Cordell Bank as possible, during a single-day survey. During several trial runs in January-April 2004 we established the approximate survey distance that could be covered during a 6-hour period. Given a 1.5-hour transit time from and to Bodega Bay, between-transect transit times, and stops for CTD casts and observations of interest, our goal was to complete the survey (dock to dock) within a 14-hour period. We considered covering both Cordell Bank and Bodega Canyon but the distance between these two features was too great to include in a single pattern. Once the Cordell Bank survey is established we may consider the addition of a second survey-day per month to cover Bodega Canyon.

A grid pattern was developed to include the entirety of Cordell Bank along with coastal-shelf and offshore-pelagic waters within 3 km of the Bank (Fig. 3). Transects are oriented east to west, a favorable direction given prevailing weather from the northwest, usually resulting in a boat orientation at 45º angle to the trough. We chose a final survey pattern consisting of eight transects (numbered and surveyed south-to-north) of 12.96 km (7 nautical miles) each in length, located 2.56 km apart, and covering a trapezoidal survey area of 12.9 X 21.2 km (Fig. 3). Thus, a maximum total of 103.7 km (56 nautical miles) are covered each survey day, which can be completed in 5.6 hours given a transect speed of approximately 10 knots. Should day length, weather, or other logistical considerations prevent time for completion of all eight transects, six transects (transects 2-7) or four transects (transects 3-6) are surveyed. It is anticipated that surveys during April-October should include all eight transects but that some surveys during November-March may need to be reduced to six or four transects due to decreased day length and (often) less-favorable weather.

Figure 5. Observers conducting survey aboard Research vessel* C. magister, *Cordell Bank.

In order to avoid bias resulting from fixed-transect selection, the starting point for the first transect is randomly chosen, among 13 points, along a 2.56-km line (Fig. 3). This ensures that the survey pattern covers the entire area (i.e., does not omit hotspots or important topographical features that may fall between fixed transects). Thus, 13 patterns have been established, one of which is randomly chosen for each survey. A program has

been written to calculate the 16 transect start-points and end-points for each pattern, and these data (in lat-long to the nearest 0.1 second) are stored in the vessel's navigational laptops for selection before each survey. This program can readily be updated to change the Cordell Bank pattern or develop other patterns for Marine Sanctuaries in the future.

Surveys are only performed when forecasts predict winds < 15 knots, visibility > 0.5 nautical miles, and seas either <6' or swell period >1.5 times swell height. Survey weeks are designated, during which observers stand by to perform surveys on the first acceptable date with favorable weather and ocean conditions. By December 2004 a team of observers (Fig. 5) had been trained for survey methods. During survey weeks, three observers are scheduled to be available on each day until the survey is successfully conducted. Following each cruise a designated observer writes a brief cruise report covering departure, survey, and arrival times; personnel; transects completed; equipment status; summary of weather and biological observations; and protocol changes or irregularities.

Biological Observations

We follow standard strip-survey methodology to survey birds, mammals, and pelagic fish and turtles. From the observation deck (Fig. 5), three trained observers survey quarter-circular and semi-circular areas, of varying radius, forward and abeam to one side of the observer's location (Fig. 6). After performing tests in various observation conditions and consulting other ocean-observing methodologies we chose an area of 200 m on one side of the vessel for all species of birds except albatross (Fig. 6). Blue Sharks, Ocean Sunfish, and Leatherback Turtles are also counted if observed in this 200-m survey area. For albatross our survey distance is 350 m on one side of the boat (Fig. 6). For pinnipeds and cetaceans ("small mammals") the survey area is 350 m on both sides of the boat (Fig. 6), resulting in a survey strip of 700 m. For large cetaceans (including all whales), our survey area extends 800 m on both sides of the vessel, resulting is a rectangular area of 800 X 1600 m (Fig. 6).

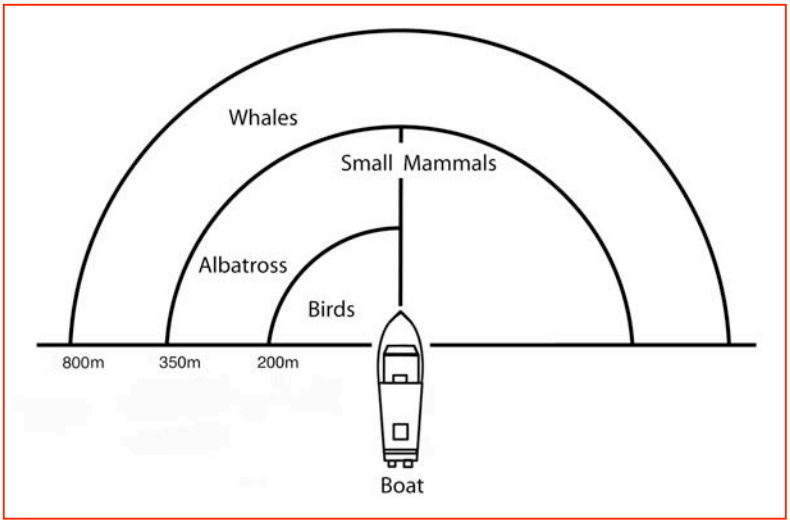


Figure 6. Survey strip distances during the Cordell Bank Ocean Monitoring Program.

In all areas, observations are binned into 100-m strips in order to better analyze our detection capabilities and for comparison with other surveys with differing detection distances. At the beginning of each survey a float attached to rod and reel is extended

100, 200, 300, and 350 m from the observation deck such that the observers can calibrate their distance estimations. For the bird-survey areas, the side of the vessel is chosen at the time based on the best lighting conditions. For all whales and smaller cetaceans observed outside of the 350-m survey area, line-transect methodology is also employed. Direction from the observers and distance is recorded when each mammal is first detected. This will enable us to compare methodologies and more fully compare our estimates with those obtained with other surveys. Binoculars calibrated with reticles are used to estimate distances (based on a 3.8-m survey height) and determine if animals are in or out of the survey areas.

Three observers conduct the marine bird and mammal survey (Fig. 5) and rotate responsibilities of bird-observing, mammal-observing, and recording. Observers can assist each other provided their responsibility is covered. Collective effort best achieves the goal of recording all vertebrates within the survey areas and reduces biases associated with species identification, numbers observed, and distance estimation (i.e., whether an individual was in or out of the survey area). Observers and observer task are recorded for each transect as variables that can be used to adjust observation totals for bias in observer detection abilities. Inter-observer variation in detection, identification, and distance-estimation skills represents the greatest potential for bias during ship-based surveys, and particular attention has been given to selecting and training highly skilled observers, and to standardizing observer effort.

All birds and mammals observed within survey areas are recorded, except birds that were sitting on the side opposite that of the survey area that were flushed by the approaching vessel into the survey area. Birds and mammals considered by the observer to have been attracted to the vessel are recorded with a note in comments. Birds (e.g., albatross and gulls) circling the boat are recorded only once, the first time they enter the area. For each bird and mammal species the number seen within each minute is recorded, along with 100-m zone, behavior code and direction of flight (for birds in transit), and age, sex, and morph if determinable. Behavior codes for birds include sitting, feeding, flying (directional), or milling (non-directional flying; e.g., in circles), and behavior codes for mammals and fish include swimming and feeding. Direction of flight is recorded from 01 to 12 according to the face of a clock, with 12 indicating a flight direction parallel to the vessel's path, 06 indicating opposite, 03 indicating perpendicular port-to-starboard (left-to-right), and 09 indicating starboard-to-port. Additional comments are encouraged.

All boats observed within 800 m (within the whale-observation area) are also recorded, along with type, activity (e.g., fishing, transiting), and direction of travel if transiting. All balloons and other flotsam inside the bird-survey area are also recorded.

Observations are binned by the minute according to digital reading (e.g., "0927" indicates individuals recorded from 0927:00 to 0927:59). Each transect will begin and end at the top of the minute (e.g., 0927:00), such that it can be divided into 60-second units of observation and compared to oceanographic data collected from the same one-minute periods. Calibrated clocks are located in the wheelhouse and on the observation deck. Ending minutes for transects indicate the minute beyond the last surveyed minute (e.g., if

the end time for a transect is 1342 the last minute surveyed was 1341). Vertebrate observational data are recorded in a notebook and entered into computer following the cruise. Following each transect, observers score abundance of *Velella velella* and three jellyfish species (*Chrysaora fuscescens*, *Aurelia labiota* and *Phacellophora camtschatica*), using an exponential scoring system ("0" = none, "1" = 1-10, "2" = 11-100, etc.). The score for *Velella* is based on the number estimated in a 2-m strip (1 m to each side of the transit line) and the scores for jellyfish are based on the number estimated in a 6-m strip (3 m to each side of the transit line) in front of the survey vessel. For each transect, quality of visibility is scored separately for birds and mammals. These scores (poor, fair, good, and excellent) represent a subjective assessment by the observer of observation conditions, as affected by visibility, spray, swell height, etc.

Breaks from survey transects (up to two per transect) are permitted to perform CTDs or to investigate interesting observations, especially large feeding flocks (at times behind trawlers) or rare birds or mammals. They also may be required at times due to boat or equipment malfunction. For each break, start and end times (on the minute) of the break are recorded and the transect re-commences at the exact location where the break occurred. In future years we will perform survey patterns through feeding flocks in efforts to understand subsurface biological and oceanographic events that result in food availability to seabirds and marine mammals.

Krill abundance is estimated with a Simrad EK60 echosounder with a single 120Khz split-beam transducer mounted on a boom arm over the starboard side of the vessel. Data are collected during the entire survey with the intent of identifying both three-dimensional spatial location (XYZ) and area-backscatter (Sa) of krill. Time and GPS coordinates are embedded in the data files for geo-referencing, and data are binned into one-minute periods to compare with vertebrate observations (see above). Sporadic net-sampling is planned for ground-truthing and calibration to develop a protocol for translating echosounder data into krill abundance (for two species, *Euphausia pacifica* and *Thysanoessa spinifera*) and other invertebrates or fish prey. In this manner we will 1) document krill variability among months, seasons and years; 2) document the spatial variability and consistency of krill aggregations; 3) test for oceanographic forcing of krill distribution and density; and 4) test for relationships between krill and vertebrate density/distributions. Data analysis will be performed with Echoview 3.1 following the methods of the *Wind to Whales* Program at U.C. Santa Cruz.

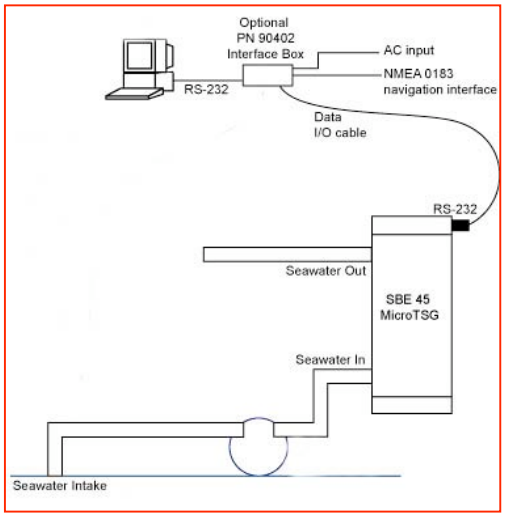


Figure 7. Operational diagram of the Sea-Bird Electronics SEACAT-SBE-19 profiler cast during CBOMP surveys.

Physical/Environmental Data Collection
Weather observations, including visibility,

wind speed, wind direction, cloud cover, swell direction, and swell height, are recorded at the start of each transect. A continuously logging surface thermo-salinograph (TSG) records location, salinity and water temperature along the entire cruise line. Data will be used to construct GIS maps relating oceanography (fronts, temperature, density, upwelling) with krill distribution and bird and mammal distribution.

CTD casts are performed at 7 locations during each cruise (Fig. 3). CTD data are collected with a Sea-Bird Electronics, Inc., SEACAT-SBE-19 profiler, rated to a depth of 600m and containing 256K of memory (Fig. 7). Four data channels are used to record pressure, temperature, conductivity, flourometry and light levels at a baud rate of 9600. The profiler is calibrated annually by Sea-Bird Electronics, Inc. The vessel is brought to a stop during the deployment and the CTD is lowered to 1 m below the surface for 1 min for equilibration. The profiler is then lowered at a rate of 40 m/minute to a depth of 5 m above the bottom or a maximum depth of 200 m. For each cast, date, transect number, cast number, GPS position, time in water, and bottom depth are recorded. The SBE-45 thermo-salinometer is plumbed to a high flow through water system and wired to Seabird optional navigation interface box where Latitude and Longitude are appended to the data stream (Fig. 7). In 2005 a WETStar miniature fluorometer, (0.03 - 75 µg/l) will be added to the CTD unit to record concentration levels of chlorophyll. CTD data will be post-processed and screened for wild points and outliers.

Data Storage and Availability

A single spatial database (Fig. 8) has been developed, holding all data streams including the temporal, spatial, and logistical aspects of each cruise; bird, mammal, and other biological observations; and physical and environmental data. Data are binned into one-minute periods (see above) and tables will be linked with fields for date, time, and transect number (see below).

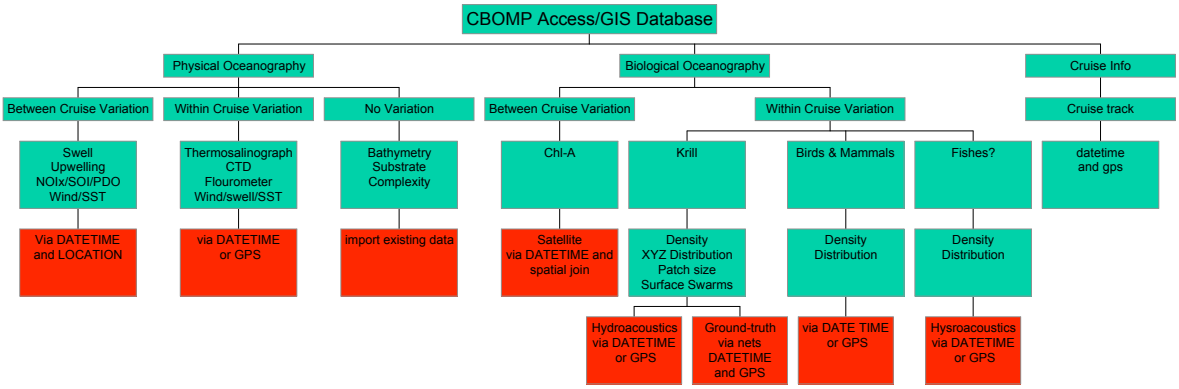


Figure 8. Database structure for Cordell Bank Ocean Monitoring Program (CBOMP).

In addition, we will capture and include data from the following sources: weather and ocean conditions collected at NOAA buoys (primarily from NDBC station 46013 off Bodega Bay; http://www.ndbc.noaa.gov/station_history.php?station=46013); sea surface

temperature derived from the Advanced Very High Resolution Radiometer (AVHRR; http://coastwatch.pfel.noaa.gov/user/dbquery_form.html); chlorophyll a concentrations from monthly composites of Seaviewing Wide Field-of-view Sensor (SeaWiFS) imagery with a spatial resolution of 9 km (seawifs.gsfc.nasa.gov/SeaWIFS.html); and upwelling and other global climactic indices (SOI, NOI, PDO, NAO, etc.) provided by NOAA/NWS (www.pfeg.noaa.gov/products/PFEL) and other sources.

Data are entered in cruise-specific files and, after proofing, are combined into master files within one week after each cruise. Our goal is to eventually have data accessible in as close to real-time as possible, so that it can be made immediately available in case of an oil spill or other event requiring immediate response. Master files are stored on both the Point Reyes National Seashore and CBNMS servers and are available as comma-delimited ASCII text files for export and exchange. Flat (spreadsheet) MS-Access files will be exported to ArcGIS for mapping and to query out and export data layers for statistical analysis. Permanent data layers housed in the GIS will include bathymetry, substrate, and slope of bottom. In time, these data and maps will be available through SIMoN, the Sanctuary Integrated Monitoring Network (http://www.mbnms-simon.org/).

A complete metadata has been developed for this database and is available through the Cordell Bank NMS.

2004 Results

Biological Observations

We completed 51 transects during eight survey dates in 2004 (Tables 1-2). Attempted surveys in February and May were cancelled due to weather, and surveys in June and July could not be attempted because of mechanical problems with the survey vessel's engine. The January, September, and December surveys were suspended due to weather (high wind/seas or fog) after 2 to 4.5 transects had been completed; all 8 transects were completed during the March, April, August, October, and November surveys. A total of 621.5 km of

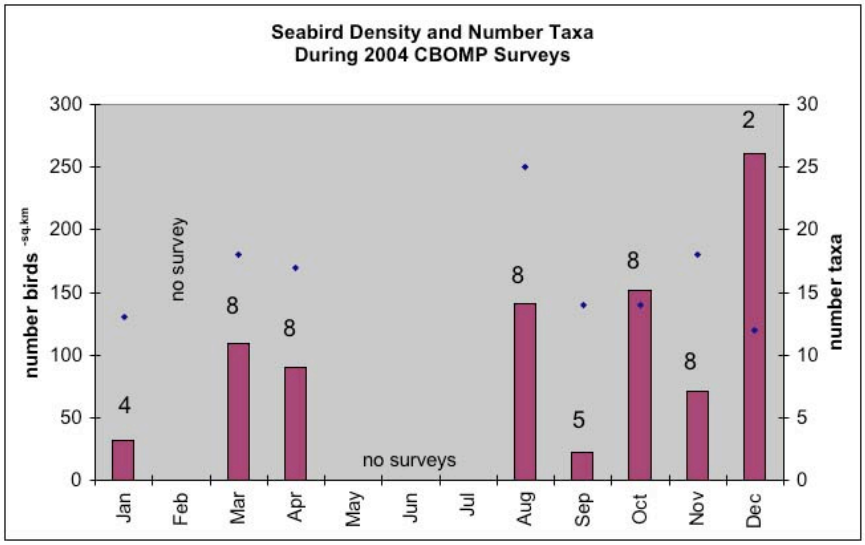


Figure 9. Seabird density (number of birds per sq. km; all species pooled and uncorrected for flight direction) and number of taxa observed (points) during Cordell Bank Ocean Monitoring Program (CBOMP) surveys conducted in 2004. Numbers over bars indicate number of transect lines completed during each survey.

transects were surveyed during 1,976 one-minute blocks, and representing a total survey area of 124.3 sq km for birds (besides albatross). Strip widths were not consistent for marine mammals during the early surveys but approximately 215 sq km were surveyed for pinnipeds and small cetaceans, and 500 sq km for large cetaceans during 2004.

A total of 12,266 vertebrates of 57 taxa were recorded during surveys in 2004 (Table 2). These included 11,594 seabirds of 40 taxa (Table 1), 503 marine mammals of 13 taxa (Table 2), and 169 pelagic fish of 3 taxa (Table 2).

Table 1 and Figure 9 summarize bird observations during the eight surveys and Figure 10 illustrates the relative abundance of the nine most commonly recorded species. Seasonal densities of birds (all species pooled) were highest in December, followed by October, August, March, April, November, January, and September (Fig. 9).

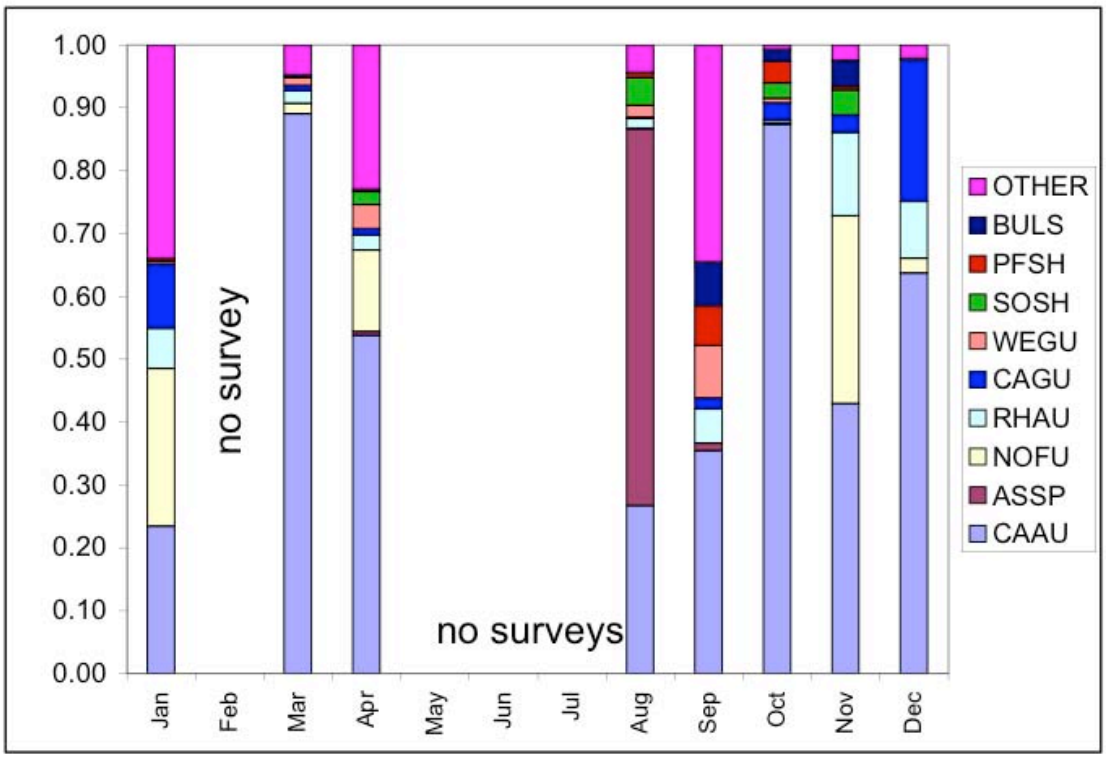


Figure 10. Relative proportion of Cassin's Auklet (CAAU), Ashy Storm-Petrel (ASSP), Northern Fulmar (NOFU), Rhinocerous Auklet (RHAU), California Gull (CAGU), Western Gull (WEGU), Sooty Shearwater (SOSH), Pink-footed Shearwater (PFSH), and Buller's Shearwater (BULS) during the Cordell Bank Ocean Monitoring Program (CBOMP) surveys conducted in 2004. See Table 1 for species designated 'other'.

Table 1. Survey lines completed, number of kilometers surveyed, species, and number of marine birds observed during the Cordell Bank Ocean-Monitoring Program (CBOMP) surveys conducted during January, March - April, and August - December, 2004. Species with asterisk (*) were selected to summarize relative abundance of numerically dominant species; all other species were grouped as 'other'.

DATE	27-Jan	29-Mar	26-Apr	31-Aug	22-Sep	13-Oct	8-Nov	13-Dec	
Survey lines completed	4	8	8	8	5	8	8	2	
Km surveyed	37	96	96	97	61	105	104	26	
TAXON									
BIRDS									TOTAL
Laysan Albatross	1								1
Black-footed Albatross	2	1	18		1	6	6	7	41
*Northern Fulmar	59	34	221	3		6	419	30	772
*Pink-footed Shearwater	1	1	6	18	22	110	8	1	167
Flesh-footed Shearwater					1		2		3
*Buller's Shearwater				4	24	59	58		145
*Sooty Shearwater		7	35	120		78	56	2	298
Short-tailed Shearwater		1	1				15		17
Manx Shearwater				1					1
Wilson's Storm-Petrel				8					8
Fork-tailed Storm-Petrel				4					4
*Ashy Storm-Petrel			10	1636	4	2			1652
Black Storm-Petrel				20					20
Least Storm-Petrel				5					5
Brown Pelican				1			1		1
Red-necked Phalarope			361	39					400
Red Phalarope			4	7	42	18	7	1	79
South Polar Skua					1	2			3
Pomarine Jaeger				2		3	1	8	14
Parasitic Jaeger			4		1				5
Long-tailed Jaeger				1					1
Bonaparte's Gull		23	20				1		44
Heermann's Gull				1		1			2
*California Gull	24	18	16	5	6	86	39	289	483
Herring Gull	34	5	1				4	12	56
Thayer's Gull	1								1
*Western Gull	1	25	66	53	29	24	74	50	322
Western X Glaucous-winged Gull		5					1		6
Glaucous-winged Gull	1	8					3	15	27
Sabine's Gull				20					20
Black-legged Kittiwake	41	17	1						59
Unidentified Gull	2	2	1						5
Elegant Tern				3					3
Common Tern				3					3
Common Murre		5		4	2				11
Xantus's Murrelet				1					1
Ancient Murrelet		34							34
*Cassin's Auklet	55	1855	919	728	123	2782	603	819	7884
*Rhinoceros Auklet	15	42	42	42	19	14	186	117	477
Tufted Puffin		1			1				2
Bird taxa	13	18	17	25	14	14	18	12	40
Bird total	237	2084	1726	2729	276	3191	1484	1351	13078

The most abundantly recorded bird was Cassin's Auklet (Fig. 10), with 7,884 individuals observed on all eight surveys (range 55-2,782 individuals). Densities were sporadic, varying from 7.42/sq km in January and 10.07/sq km in September, to 131.85/sq km in October and 158.11/sq km in December. We suspect that this may reflect variation in krill abundance (Fig. 11) and hope to confirm such a correlation in future years.

The next most abundant species recorded were Ashy Storm-Petrel (1,652 of which 1,636 were observed on the August survey), Northern Fulmar (772), California Gull (483), Rhinoceros Auklet (477), Red-necked Phalarope (400 of which 361 were recorded on the April survey), Western Gull (322), Sooty Shearwater (298), Pink-footed Shearwater (167), and Buller's Shearwater (145) (Table 1, Figure 10). Unusual species recorded included Laysan Albatross (1 in January), Manx Shearwater (1 in August), Black and Least storm-petrels (20 and 5, respectively, in August), and Xantus' Murrelet (1 in August).

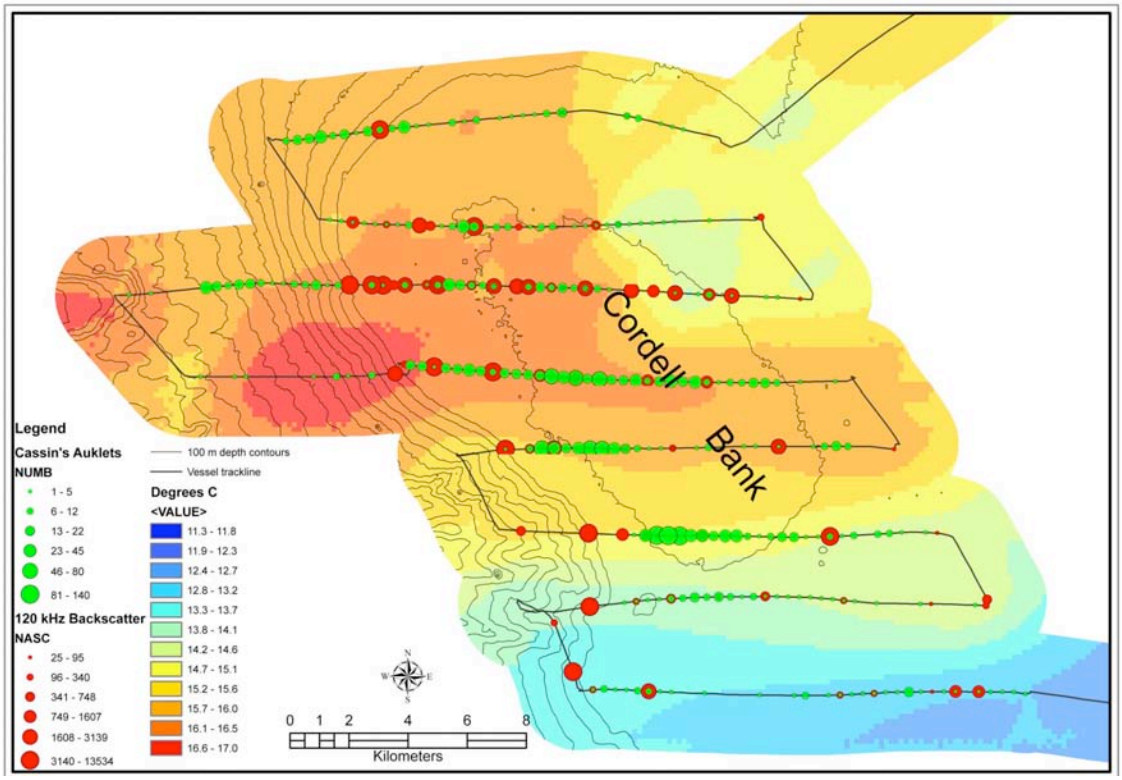


Figure 11. Locations of Cassins Auklets and 120 kHz echosounder backscatter for 13 October 2004. Backscatter along shelf-break is likely krill.

Table 2 and Figure 12 summarize marine mammal observations during the eight surveys. The most abundantly recorded marine mammals were Pacific White-sided Dolphin (250 of which 215 were recorded in August), Humpback Whale (144 of which 104 were recorded in November), Dall's Porpoise (70), California Sea Lion (51), and Blue Whale (37). Nineteen of the Endangered Steller Sea Lions were recorded on five of the eight surveys. The most unusual marine mammal recorded was a cetacean thought possibly to be a hybrid Dall's X Harbor porpoise, observed on the September survey (recorded as unidentified cetacean).

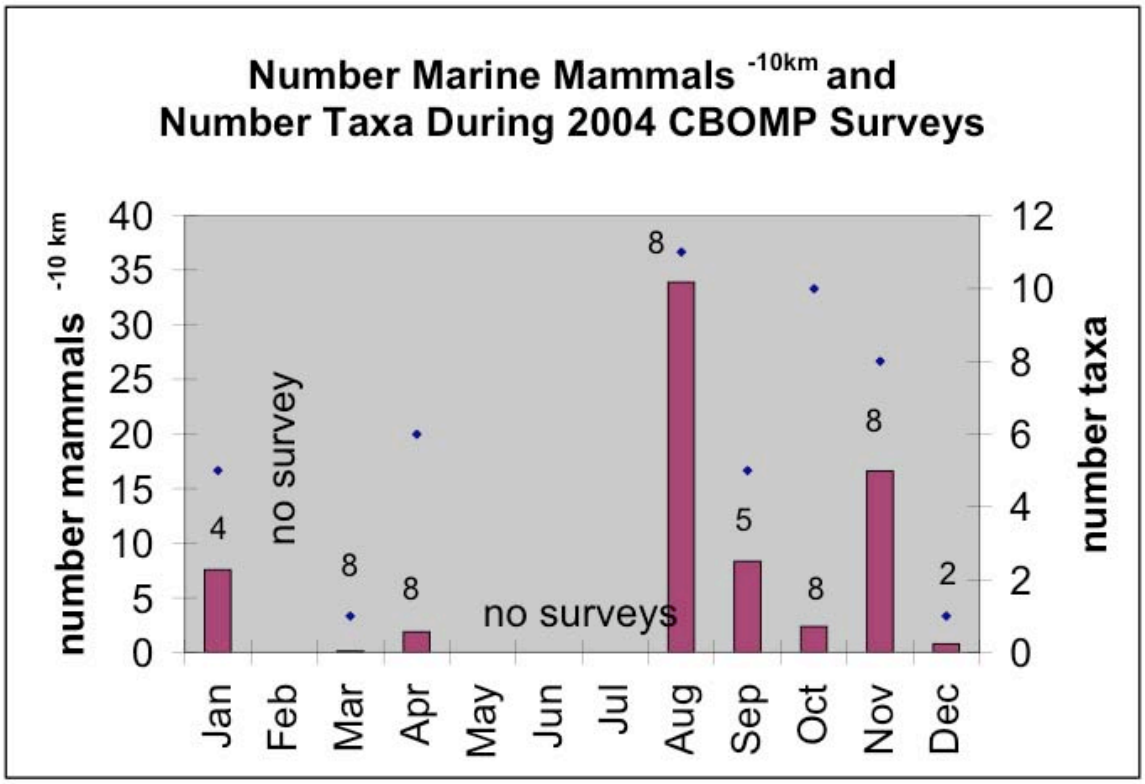


Figure 12. Number of marine mammals per 10 kilometers surveyed (bars) and number of taxa observed (points) during surveys conducted during 2004. Numbers over bars indicate number of transect lines completed during each survey.

Small marine mammal (small cetacean and pinniped) densities were highest in August (approximately 8.73/sq km) followed by January (2.16), September (1.64), November (1.18), October (0.60), April (0.54), December (0.22), and March (0.03). Large cetacean densities were highest in November (approximately 1.57/sq km), followed by August (0.43), September (0.33), and October (0.04); no large cetaceans were observed in January, March, April, or December.

Of the three fish species recorded, the most abundant was the Blue Shark (145 recorded) (Table 1). By far the best survey for fish was that of August, during which 137 Blue Sharks, 14 Mola Mola, and 2 alabcore were censused.

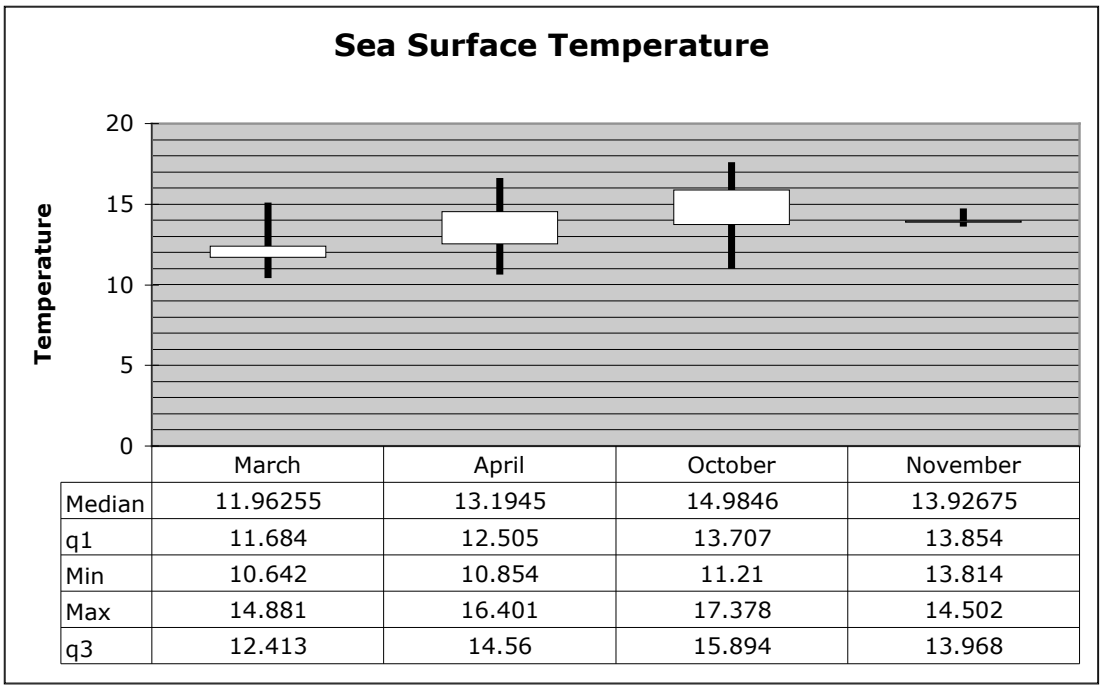
Abundance of *Vellela vellela* was not surveyed in January and none were recorded in August-December. Highest densities were recorded in April (approximately 4/sq m [4,000,000/ sq km]), followed by March (0.9/sq m [900,000/sq km]). Jellyfish were only scored during the September-December surveys and none was recorded in December. The most abundant species was *Aurelia labiota* with approximate densities of 36/sq km in September, 134/sq km in October, and 19/sq km in November. For *Phacellophora camtschatica* we recorded approximate densities of 17/sq km in September, 11/sq km in October, and 7/sq km in November. The only month in which *Chrysaora fuscescens* was recorded was September (3/sq km).

Table 2. Survey lines completed, number of kilometers surveyed, species, and number of marine mammals, fishes, vessels, and balloons observed during the Cordell Bank Ocean-Monitoring Program (CBOMP) surveys conducted during January, March - April, and August - December, 2004. Species with asterisk (*) were selected to summarize relative abundance of numerically dominant species; all other species were grouped as 'other'.

DATE	27-Jan	29-Mar	26-Apr	31-Aug	22-Sep	13-Oct	8-Nov	13-Dec	
Survey lines completed	4	8	8	8	5	8	8	2	
Km surveyed	37	96	96	97	61	105	104	26	
TAXON									
MARINE MAMMALS									
									TOTAL
Northern Fur Seal	2	1	1	2	0	7	3	0	16
Steller Sea Lion	5	0	7	2	0	4	1	0	19
California Sea-Lion	3		1	34		3	8	2	51
Northern Elephant Seal			2	1		2	4		9
Unidentified Pinniped				1	2	1			4
Minke Whale						1			1
Blue Whale				2	7	2	26		37
Humpback Whale				31	8	1	104		144
Unidentifiied Whale					1				1
Pacific White-sided Dolphin	14			215		1	20		250
Northern Right-whale Dolphin				1		3			4
Risso's Dolphin				14					14
Dall's Porpoise	4		1	26	32		7		70
Unidentified Cetacean			6		1				7
Mammal taxa	5	1	6	11	5	10	8	1	14
Mammal total	28	1	18	329	51	25	173	2	627
FISH									
Blue Shark			1	137	1	4	2		145
Tuna sp. (prob. Albacore)				2					2
Mola Mola			1	14		1	6	1	23
Fish taxa			3	3	2	2	2	1	3
Fish total			8	153	2	5	8	1	177
TOTAL TAXA	18	19	26	39	21	26	28	14	57
GRAND TOTAL VERTEBRATES	265	2085	1752	3211	329	3221	1665	1354	13882
OTHER									
Boat			3	2	1	1	2		9
Balloon			3				2		5

Physical/Oceanographic Observations

In 2004 TSG data were collected in March, April, October and November (Figure 13). Median temperatures ranged from 11.96° C in March to 14.98° C in October. Temperature variation was lowest in November and greatest in October. These data correlate well with those downloaded from the SeaWiffs Satellite imagery. We anticipate that greater variation in SST will reflect greater ocean mixing, increased frontal activity, and/or an infusion of warmer offshore water. We look forward to comparing this variation with vertebrate abundance in a spatial context (onshore/offshore and North/South).



	March	April	October	November
Median	11.96255	13.1945	14.9846	13.92675
q1	11.684	12.505	13.707	13.854
Min	10.642	10.854	11.21	13.814
Max	14.881	16.401	17.378	14.502
q3	12.413	14.56	15.894	13.968

Figure 13. Median, SD and range for sea-surface temperature recorded with on board themosalinometer on four CBOMP cruises in 2004.

Twenty-two CTD casts were deployed during September, October, November and December 2004 cruises. During September through December, CTD casts showed stratified and un-stratified profiles, which appeared to reflect wind conditions. A cold water cell was embedded in the warmer water between 50 and 100meters and was apparent in profiles 4-6 in the late fall. We look forward to investigating this further.

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