Survey Data

The BTS of the EBS continental shelf are conducted annually by the Resource Assessment and Conservation Engineering (RACE) division of the Alaska Fisheries Science Center. The main purpose of the BTS is to collect biological data for estimating abundance and the age- and sex-composition of commercially important species of fish and crab for use in annual stock assessments. Bottom trawl tows are performed over a grid of stations in the EBS from late spring through mid-summer. The survey begins in eastern Bristol Bay with two vessels generally proceeding westward by column, working westward across the EBS shelf.

Paired depth-temperature data were routinely collected at each station during the BTS. The data from successful casts were recorded and entered into RACE's database in one of two ways depending on the year. From 1982 through 1989 (on all vessels) and in 1990 on the survey vessel Ocean Hope 3, depth-temperature traces were determined using expendable bathythermographs (XBT). Graph-paper traces from XBT casts were later converted to depth-temperature data pairs through visual examination, especially transcribing inflection points to describe the depth-temperature profile. In 1990 on the R/V Alaska, and from 1991 to 1992 on all vessels, the XBT graphical recordings were replaced by digital traces stored on a computer. Starting in 1993, digital bathythermograph recorders (BTR) were attached to the headrope of the trawl net in place of using XBTs. The data recorded during the downcast of the net, from the surface to the bottom, were selected for inclusion in the RACE database. In a few cases, however, the surface portion of the profile was excluded which resulted in the shallowest reading at a depth below 10m in the RACE database.

We corrected anomalous depth-temperature pairs where possible. Frequency distributions of the depth at which particular temperatures and water column features occurred, suggested substantial anomalies in some of the profiles originally recorded on graph-paper. The anomalies were traced back to a mismatch between the drum-gearing (which controls the advance-speed of the graph-paper) and the scale on the graph-paper. Consequently, depths were under-stated by a factor of 2.54 for some profiles in 1985, 1986, 1987, 1989 and 1990. For our analyses, we corrected the depth values and removed the depth-temperature data when they were deeper than the sea floor.

Data from graphically recorded profiles sometimes required the addition of data points for our analyses. In some years, temperature profiles start at the surface and in other years they start at a depth of 5 meters. Profiles without a temperature record at 5 or 6m were modified using interpolation between straddling points to estimate the temperature at the 5.5m depth; this data point was added to the profile. We only used depth-temperature data points that were 5m and deeper in our analyses. Some profiles did not have a bottom depth-temperature data point because only the deepest inflection point was recorded. A subsample of archived depth-temperature traces was examined to confirm that this was the case. To complete the depth-temperature profile, we appended the bottom depth-temperature record to the existing data in the profile by adding the gear depth and gear temperature when the gear depth (depth of the trawl headrope) was 5m deeper than the existing deepest depth-temperature data pair. If the gear temperature was missing, then the temperature of the last inflection point was replicated at bottom depth. Unusual changes in temperature with depth were checked against the original depth-temperature traces from that station and neighboring stations to confirm or correct the data if possible. Profiles originally recorded on graph-paper were described by relatively few data points compared to profiles recorded directly into computer memory.

Data recorded into computer memory had relatively high numbers of data points describing the depth-temperature profile at each station, and in most cases some data points were excluded. Depth-temperature data from depths shallower than 5.5m were deleted to exclude data recorded while the net was towed near the surface in the turbulent wake and propeller-wash of the vessel prior to deployment to the bottom. Multiple temperature readings at the same depth were replaced by an average temperature value for that depth. Cursory examination of the resulting statistics indicated there were some profiles with unusually messy data or multiple profiles. These were corrected where possible, or they were culled from the available profiles for our analyses if the data were not correctable.

Depth-temperature profiles from the RACE database are also being archived at the Pacific Marine Environmental Laboratory (PMEL) from the 1994 BTS onward (Peggy Sullivan, pers. comm.). At PMEL the temperature data are averaged within 1m depth bins. Near-surface data are extrapolated to the top, and spurious points are removed. The data are visually inspected for reasonableness, especially the near-surface, bottom layer and mixed layer values. These data are made available through two web interfaces at PMEL: http://www.epic.noaa.gov/epic/ewb/ and http://dapper.pmel.noaa.gov/dchart/ (Peggy Sullivan, pers. comm.).

Water Column Characteristics

Three types of statistics were calculated on the resulting depth-temperature profiles. The first group of statistics describes nominal temperature characteristics. Maximum and minimum temperatures were listed for each profile, as well as the temperatures and associated depths for the top (usually 5.5m depth) and bottom of each profile. The differences between top and bottom temperatures and between maximum and minimum temperatures were also calculated. Other nominal temperature statistics included description of the depth and thickness of the “cold pool” layer defined in two ways; by water ≤ 2°C and by water ≤ 0°C. The second group of statistics describes the mixed and transition layers, the average temperature of the surface and bottom mixed layers, and the average rate of temperature change (°C m^{-1}) within the transition layer (when one existed) occurring between the mixed surface and bottom layers. The third group of statistics describes the strength and depth of the maximum temperature gradient, or thermocline (TCmax, the maximum rate of temperature decrease with depth, °C m^{-1}) in the depth-temperature profiles.

Standardizing Procedures

To standardize the descriptive statistics between the two collection methods, the two types of data required different handling. The minimal number of data points transcribed from the graphical traces (1982-1990) required interpolation to locate the depths associated with particular temperature values. In contrast, the digitally recorded profiles (1990-2006) sometimes had data points too close together for the automated process to correctly locate the maximum thermocline (TCmax) based on comparison of the statistic (calculated from the raw data) and visual examination of the depth-temperature plot. Temperature readings were recorded to the nearest 0.1°C and depths were recorded to the nearest 0.1m.

For data recorded directly into computer memory (1990-2006), two procedures, "averaging" and "weeding" of the data, were used to increase the distance between consecutive points, and the results were compared. Averaging consisted of taking the average temperature and the average depth of the data in each 1m bin throughout the depth-temperature profiles. Weeding consisted of sub-sampling the depth-temperature data pairs and keeping the data pair that occurred closest to the whole meter in each 1m bin. When data pairs occurred equidistant from the whole meter (for example, 10.8m and 11.2m), the deeper reading was used. TCmax values were located in the depth-temperature data-pairs resulting from averaging and from weeding at each station. A scatter-plot of the TCmax values based on averaging and weeding was examined. The difference in thermocline depths between the two methods was plotted against the difference in thermocline strength between the two methods. When differences in thermocline strength were ±0.25°C m^{-1} or more, we examined the original data plots and raw data of the depth-temperature profile to understand the discrepancies.

Annual Survey Indices

Indices based on the profile statistics were calculated for the standard survey area (1982-2006) and for the extended survey area (1987-2006). We compensated for the interannual variability in the number of stations with depth-temperature profiles by weighting each profile by the area of the Thiessen polygon - an area determined by the location of the surrounding stations that also have depth-temperature profiles. Indices for average bottom temperature, volume of the cold pool, volume and average temperature of the surface mixed layer, volume and average thermocline of the transition layer, and the average TCmax were calculated. We examined the correlation between some of these indices that we would expect to have a relationship based on oceanographic processes in the EBS. Because these indices are influenced by variation in the timing of the survey, the start, end, mean and median annual Julian day of the survey were also calculated. We examined the variation in timing and duration of the BTS for patterns or trends that could influence interpretation of the survey indices as a time-series.