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Using inorganic carbon measurements from an international survey effort in the 1990s consisting of 9618 hydrographic stations collected on 95 cruises and a tracer based separation technique (ΔC^*), we estimate a global oceanic anthropogenic CO_2 sink for the period from 1800 to 1994 of 118±19 PgC. Variations in surface concentrations of anthropogenic CO_2 are related to the length of time that the waters have been exposed to the atmosphere and to the buffer capacity, or Revelle Factor, for seawater. Currently, approximately 30% of the anthropogenic CO_2 is found shallower than 200 m and nearly 50% above 400 m depth. The global average depth of the 5 μmol kg^{-1} contour is 1000 m. About 60% of the inventory is found in the Southern Hemisphere. The oceanic sink accounts for ~48% of the total fossil fuel and cement manufacturing emissions between 1800 and 1994, implying that the terrestrial biosphere was a net source of CO_2 to the atmosphere of about 39±28 Pg C for the period. By contrast, over the last 20 years the net terrestrial biosphere is thought to be a sink for anthropogenic CO_2 of about 15±9 Pg C. Over the last 20 years, the percentage of anthropogenic emissions taken up by the oceans appears to be smaller than over the last 200 years. The current fraction of total anthropogenic CO_2 emissions stored in the ocean appears to be about one third of the long term potential.

PICES XIII S8-2069 Poster
CO_2 is HOT: Fifteen years quantifying carbon dioxide in the subtropical Pacific Ocean

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The Hawaii Ocean Time-series (HOT) program has continuously measured the oceanic carbon dioxide system for 15 years at Station ALOHA in the subtropical North Pacific Ocean near Hawaii. Samples are collected approximately monthly using a rosette system fitted with a SeaBird CTD. Dissolved inorganic carbon (DIC) and total alkalinity (TA) samples are returned to our shore-based laboratory and analyzed using semi-automated coulometry and open-cell titration techniques, respectively, following methods recommended by the Department of Energy (DOE). pH is determined spectrophotometrically at-sea also following DOE guidelines. The accuracy of these measurements is maintained using certified seawater reference materials. Precision for measurement of DIC is better than 1 μmol/kg and for TA it is better than 2 μmol/kg. Precision of pH measurements is 0.001 pH units with an estimated accuracy of 0.004 pH units. We are in the process of procuring a new underway pCO_2 system. HOT program data are accessible online using HOT-DOGS - the Hawaii Ocean Time-series Data Organization & Graphical System located at: http://hahana.soest.hawaii.edu/hot/hot-dogs/interface.html. A list of publications based on the HOT CO_2 time-series is accessible at: http://hahana.soest.hawaii.edu/hot/hotpub.html. Key findings include: The distributions of DIC, TA and pH are controlled by both physical and biogeochemical processes. A seasonal cycle of DIC in the surface water reveals the waters around Hawaii are a net sink for CO_2. An inventory shows the surface ocean accumulating DIC consistent with increasing atmospheric CO_2. The strength of the CO_2 sink is strongly influenced by regional changes in precipitation and evaporation due to climatic variability.

PICES XIII S8-1893 Oral
Seasonal change in surface pCO_2 distribution in the East China Sea

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Surface pCO_2, temperature, salinity, nutrients, and chlorophyll *a* were measured in the East China Sea (31~34 °N, 124~128 °E) from August 26 to September 2, 2003, and from April 28 to May 7, 2004. The high-salinity Tsushima Warm Current was observed in the eastern portion of the survey area in both years. Consequently, temperature and

salinity showed similar distributions in the summer of 2003 and the spring of 2004. By contrast, the surface pCO_2 changed dramatically from summer to spring across the shelf front, where the Tsushima Warm Current meets Yellow Sea water. High pCO_2 (> 380 μatm) in the east, and low pCO_2 (< 280 μatm) in the west, off China, were observed in the summer of 2003, and the pattern was reversed in the spring of 2004. Surface pCO_2 was positively correlated with temperature in the eastern portion of the shelf front in both summer and spring (r=0.82 and 0.74, respectively). Therefore, east of the front, temperature is thought to primarily control surface pCO_2, while west of the front it is controlled by many factors, such as fresh water discharge from Yangtze River in summer, water stability, primary productivity, and organic decomposition. The highly elevated pCO_2 west of the front in spring despite the low temperature and high chlorophyll concentration might be the result of surface water mixing with CO_2-rich bottom waters in spring or massive fresh water discharge from the Yangtze River in summer.

PICES XIII S8-1917 Poster
Variability in the degree of saturation for CFCs in the North Pacific Central Mode Water

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We made observations of chlorofluorocarbons (CFCs) in seawater along 165°E in the western North Pacific in spring. In the North Pacific Central Mode Water (NPCMW), as defined by the lower potential vorticity below the seasonal thermocline that is formed between the Kuroshio Bifurcation Front and Kuroshio Extension Front, CFC-12 have been significantly under-saturated (~96%) with respect to the atmospheric CFC-12, and the degree of under-saturation has changed year by year. Since the mode water is formed through deep vertical convection in the surface layer in winter and is considered not greatly influenced by mixing with ambient waters during the subsequent advection into the interior of the ocean, these results suggest that CFCs in the mixed layer in winter were already under-saturated with respect to the atmospheric CFCs. It is also found that the density of NPCMW is changing year by year, which suggests that the mixing ratio of subtropical water and subarctic water to form NPCMW is changing year by year. On the basis of these results, the relationship between the density and degree of CFCs under-saturation is also to be presented.

PICES XIII S8-2134 Poster
Temporal and spatial variation of dissolved inorganic carbon in the western North Pacific in recent years

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Temporal and spatial variations of dissolved inorganic carbon (DIC) in the western North Pacific were reassessed using the recent time-series data and cross-sectional data sets since the 1990s. DIC in the surface seawater have been determined by the Japanese ocean time series program at station KNOT (155°E, 44°N) from 1998 to 2004. The seasonal amplitude of DIC was more than 100 μmol/kg, which is larger than those of existing pelagic ocean time series sites. This large variation is mainly due to the biological production in spring to fall and strong vertical mixing in winter. Applying the equation of the Fourier sine expansion (Tanaka et al., 2003: GRL, 10.1029/2003GL018593), we estimated the increase rate of DIC in surface seawater at 1.0 μmol/kg/year. This value closely approximated the expected value under the equilibration between air and sea at KNOT. On the other hand, the increase rates of DIC were more variable in the intermediate and deep sea waters. We estimated the increase rates of DIC using the isopycnal data in 1992 and 2000 along the 165°E north-south transect. Increase rates of DIC were several times larger than the predicted values estimated only from the influence of anthropogenic carbon, especially in mid to high latitude areas. The distribution of DIC increase rates in the transect showed similar patterns with that of AOU. This suggests the possibility that the change of water circulation significantly influences the carbon cycle in the ocean.