6. Water Quality Status of Georgia Estuaries and Coastal Waters

We used the water quality data collected by GA DNR CRD to assess the status of Georgia estuaries and coastal waters, insofar as possible, according to the criteria recommended in the Indicators section. We were able to assess status for pH, dissolved oxygen (DO), and total dissolved phosphorus (TDP) according to the criteria. We assessed nitrogen status using dissolved inorganic nitrogen (DIN) compared to criteria derived assuming that DIN is a constant fraction of total dissolved nitrogen (TDN). We had no data to assess chlorophyll *a* and BOD, and the turbidity data collected by CRD are not directly relatable to the recommended transparency criteria.

Methods

Status evaluations are based on calendar years. Our general procedure was to query the database for each parameter for each site for each calendar year. Values below the parameter's minimum detection limit (MDL) were raised to the MDL in order to process the data consistently. The data were then examined to see if a sufficient number of observations existed to assess status for that site over the calendar year. Data were deemed sufficient or not according to rules describing minimum numbers of samples and evenness of sampling, as described below.

For parameters without a well-defined seasonal cycle (pH, DIN, TDP), we set the minimum number of samples as 5 to be able to use information from bimonthly sampling with one potentially missing or bad sample. Evenness of sampling over the year was assessed by establishing a maximum gap between samples of 92 days (which covers the largest possible quarterly gap e.g. July 1 to September 30). Unless otherwise noted below, the criteria were: 1) there must be a sample in the first 92 days of the year; 2) there must be a sample in the last 92 days of the year; and 3) there must be no gap between samples of more than 92 days. Any site data not meeting these criteria would be missing an entire quarterly season and would therefore not represent a sufficient annual sample. Annual medians were used to evaluate the status of DIN and TDP whereas pH was evaluated using median as well as minimum and maximum values.

DO status was evaluated using both annual median and annual minimum values. Annual median was treated as described above, with the same criteria of at least 5 samples distributed over the year. DO has a well-defined seasonal cycle that permitted somewhat more relaxed criteria for sufficient data to calculate the annual minimum. Of 1005 combinations of site x year in the database, the month having minimum DO was in the range June-October 93% of the time; therefore, we designated these months as the critical period for sufficient DO data. We only evaluated years when there were at least 2 samples during this period, with a maximum gap of 92 days for this period rather than the entire year. However, if a site met the criteria for sufficient data during the critical period, then all data for the calendar year were used to calculate the minimum (in the unlikely event that the minimum occurred at a different time of year).

Once indicator metric values were calculated, they were then compared with the recommended criteria for each parameter to assign status values of "good", "fair", or "poor". In the maps and tables that describe water quality status, a value is shown only if sufficient data were available. Sites with insufficient data are omitted from maps and indicated with a gray box in tables.

Status

Annual water quality status for each site with sufficient data according to the criteria described above is included in Appendix B. General conclusions about each status parameter are described below.

pH

pH status was assessed using ΔpH, the deviation from the expected pH according to the sample salinity and estuary type (see Correlations and Indicators sections for these relationships). The annual minimum is

therefore the most extreme negative deviation, and the annual median is the median deviation. The annual median deviations can be expected to be near zero because expected or normal values were derived from the observations themselves. The advantage of using ΔpH is that "good/fair" and "fair/poor" criteria of 0.5 and 1 unit deviation (respectively) from established pH-salinity relationships can be applied across all estuary types.

Even though pH measurements began in 2002 at River and Sound sites and in 2003 at Shellfish sites, sampling was too sporadic to evaluate annual metrics until 2004. Annual minimum pH deviations often ranged into the fair and poor categories because annual variation in ΔpH at individual sites can be on the order of 1 pH unit or more (Figure 6-1.) During 2004 ten sites, mostly in the Ogeechee and St. Marys rivers, were classified as poor in terms of their minimum pH. The Ogeechee River sites improved during 2005, but sites in Altamaha, Doboy, and Sapelo sounds declined compared to 2004. pH conditions were generally better coastwide in 2006, with no sites classified as poor. Only Beach site data were available in 2007-8: Jekyll Island sites showed a marked decline in 2008 compared to previous years.

As expected, annual median pH deviations were low. Median pH status was classified as good at all sites in all years except for two sites in 2006 (Figure 6-2). One site in Hampton Sound barely reached fair status, and one site in the St. Marys River had a median deviation of 0.6 above normal, which indicates fair status but high pH may be less of a concern than a low value.

Dissolved Oxygen

Dissolved oxygen (DO) measurements began in March 2000 for most Shellfish, River, and Sound sites, so in most cases partial year data were sufficient to calculate both annual minimum and annual median values. Beach site sampling began in April 2004, so for that year most Beach sites had only enough data to calculate an annual minimum but not a median.

Annual minimum DO in Georgia coastal waters was generally fair to poor over the study period (2000-2008), with few sites ever remaining in good condition throughout a calendar year (Figure 6-3). Zones of low DO water were concentrated in the southern estuaries in 2000 and in the northern estuaries in 2002, but in most years water classified as poor was found sporadically along the coast. Minimum DO was markedly poorer coastwide in 2003 than in other years, with 65% (81 of 125) of the sites classified as poor and the remaining 35% classified as fair. These proportions improved in later years, with an average of 10% of sites classified as poor and 87% classified as fair in 2004-2006. Annual median DO was generally good to fair over the study period, with no sites having poor annual median DO in any year (Figure 6-4). Most of the sites that were classified as poor in terms of annual minimum DO (Figure 6-3) were classified as fair in terms of annual median DO. This indicates that lower DO values were observed at least half the time over the course of a year rather than during a brief episode. Median DO was also markedly poorer coastwide in 2003 than in other years, with only 13 sites (out of 125) classified as good. These were mostly in Altamaha and Doboy sounds. Median DO was considerably better coastwide in 2006 than in other years, with all but three sites classified as good (and these three sites had DO concentrations at the upper end of the fair range).

Dissolved Inorganic Nitrogen (DIN) as a Proxy Nitrogen Indicator

The indicator criteria were developed to evaluate TDN as the most important nitrogen fraction for overall water quality; however, CRD has so far collected only dissolved inorganic nitrogen (DIN) measurements. In order to have at least a rough estimate of the nitrogen status of Georgia coastal waters, we evaluated DIN concentrations for this report. DIN is the sum of the component measurements of ammonia, nitrite, and nitrate (as mg N L^{-1}). Each of these component values were raised to the MDL if necessary before summing. As described in the Indicators section, we assumed that DIN is approximately 25% of TDN in Georgia coastal waters; therefore, we compared DIN to criteria representing 0.25 times the recommended TDN criteria: 0.025 and 0.25 mg N L^{-1} for "good" and "fair", respectively.

DIN measurements began in July 2001 at Sound sites, August 2001 at Shellfish sites, and July 2002 at River sites. Nutrient measurements were not collected at Beach sites. No sites had sufficient data to evaluate annual metrics in 2001, and River sites had insufficient data in 2002, so we could only evaluate nutrients for the period 2002-2006.

Annual median DIN was fair at most sites during the study period: between 2003 and 2006 an average of 92% of sites were classified as fair. Sites classified as poor were located in the Altamaha River (Figure 6-5). Only a few sites sporadically showed good annual status.

Total Dissolved Phosphorus (TDP)

Total dissolved phosphorus (TDP) measurements began in October 2001 at Sound and Shellfish sites and in July 2002 at River sites so, as for DIN, we could only evaluate nutrients for the period 2002-2006.

Annual median TDP remained fair at all sites throughout the study period (Figure 6-6).

Multiple Criteria

Another way to evaluate status is to examine individual sites to determine if a site ranked as poor in more than one category or year. If this were the case it might suggest a larger problem at this location. Starting in 2003 there were measurements of both DO and nutrients at Shellfish, River, and Sound sites, and from 2004-6 pH is also available. In 2003 annual minimum DO was classified as poor at 81 sites (Figure 6-3). Of these only sites in the Altamaha River were also classified as poor in terms of DIN (Figure 6-5). In 2004 there were two sites in the St. Marys River that were classified as poor in terms of both their annual minimum pH (Figure 6-1) and DO (Figure 6-3), and one site in the Altamaha River classified as poor for minimum pH (Figure 6-1) and median DIN (Figure 6-5). This was similar to 2005, when two sites in the St. Marys River and one in St. Andrew Sound were classified as poor in terms of minimum pH (Figure 6-1) and DO (Figure 6-3) (note that only one of the St. Marys sites had also shown two poor measurements in 2004). In 2006 no sites were classified as poor in more than one category. This suggests that poor water quality was sporadic, with no locations standing out in particular.

The differences in numbers of poor status sites between years can also be evaluated. 2003 had numerous sites classified as poor in terms of minimum DO, with most other observations (median DO, DIN, and TDP) classified as fair. This improved in 2004, with minimum DO improving to fair and median DO improving to good at most sites. 2005 and 2006 were similar to 2004 in terms of DO, but there was improvement in pH. These results will need to be extended to be able to say anything definitive about long-term trends, but they suggest that water quality was poorer in 2003 compared to later years.

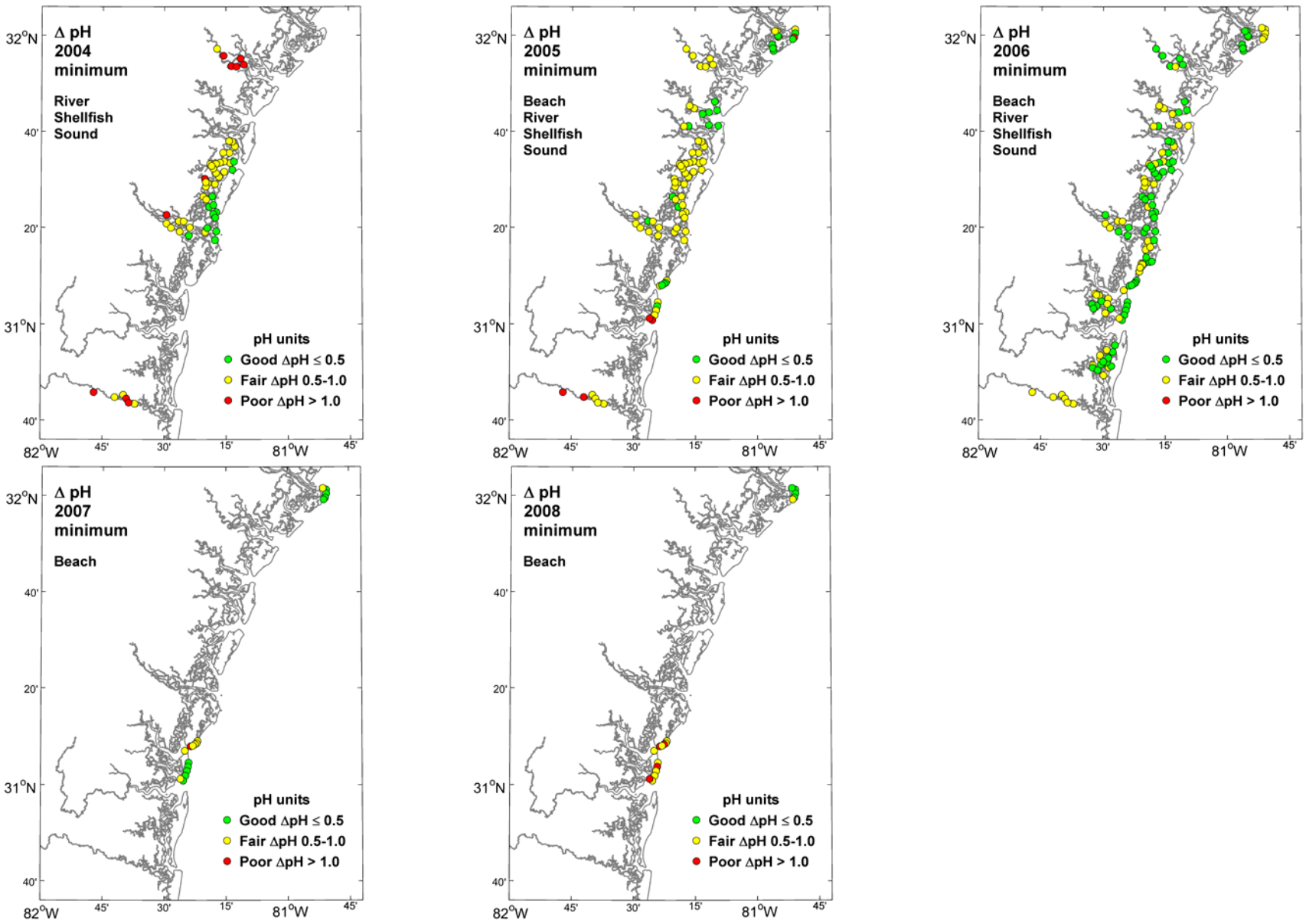


Figure 6-1. Annual minimum pH deviation status at sites sampled by GA DNR CRD during 2004-2008 for programs noted on maps.

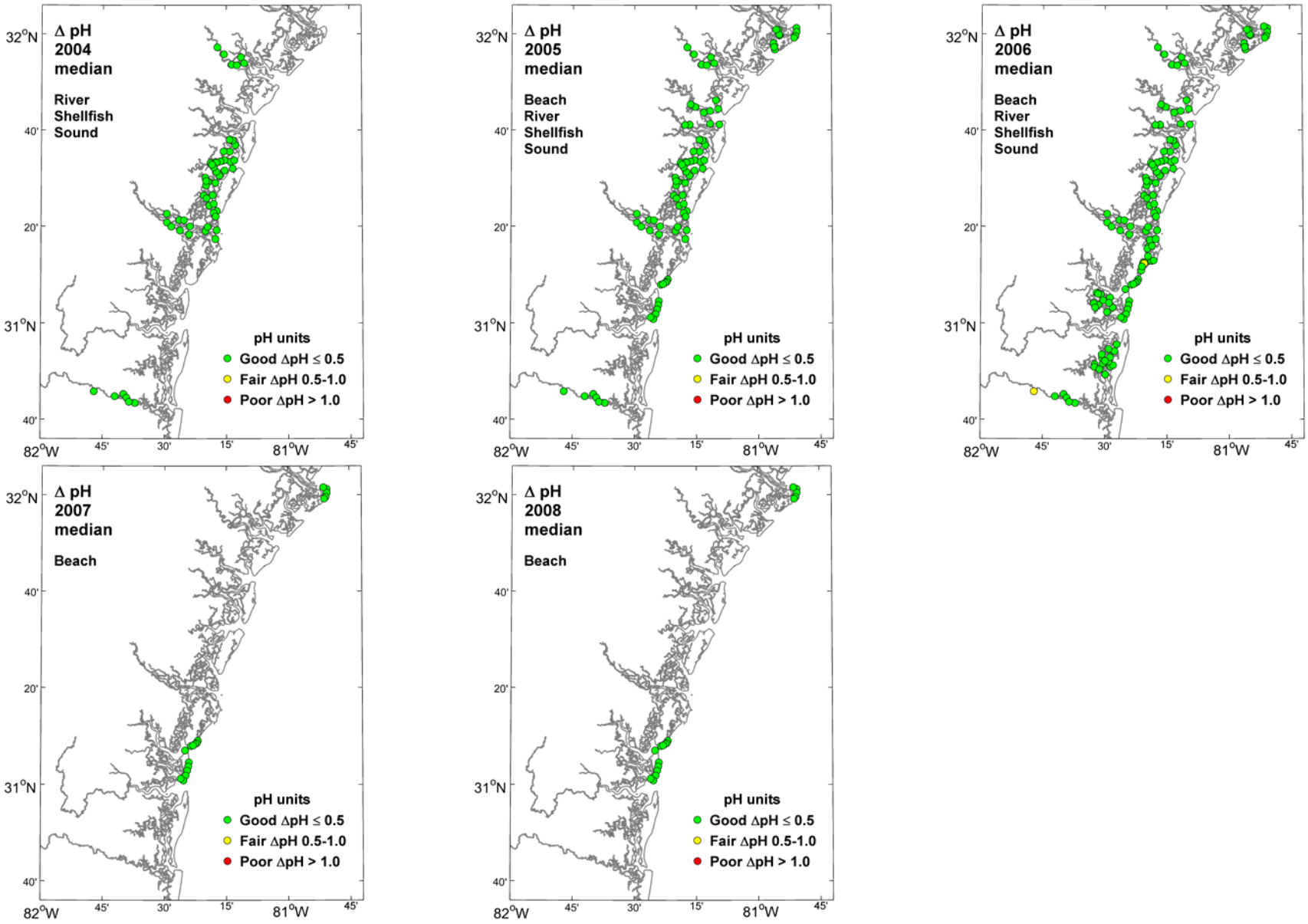


Figure 6-2. Annual median pH deviation status at sites sampled by GA DNR CRD during 2004-2008 for programs noted on maps.

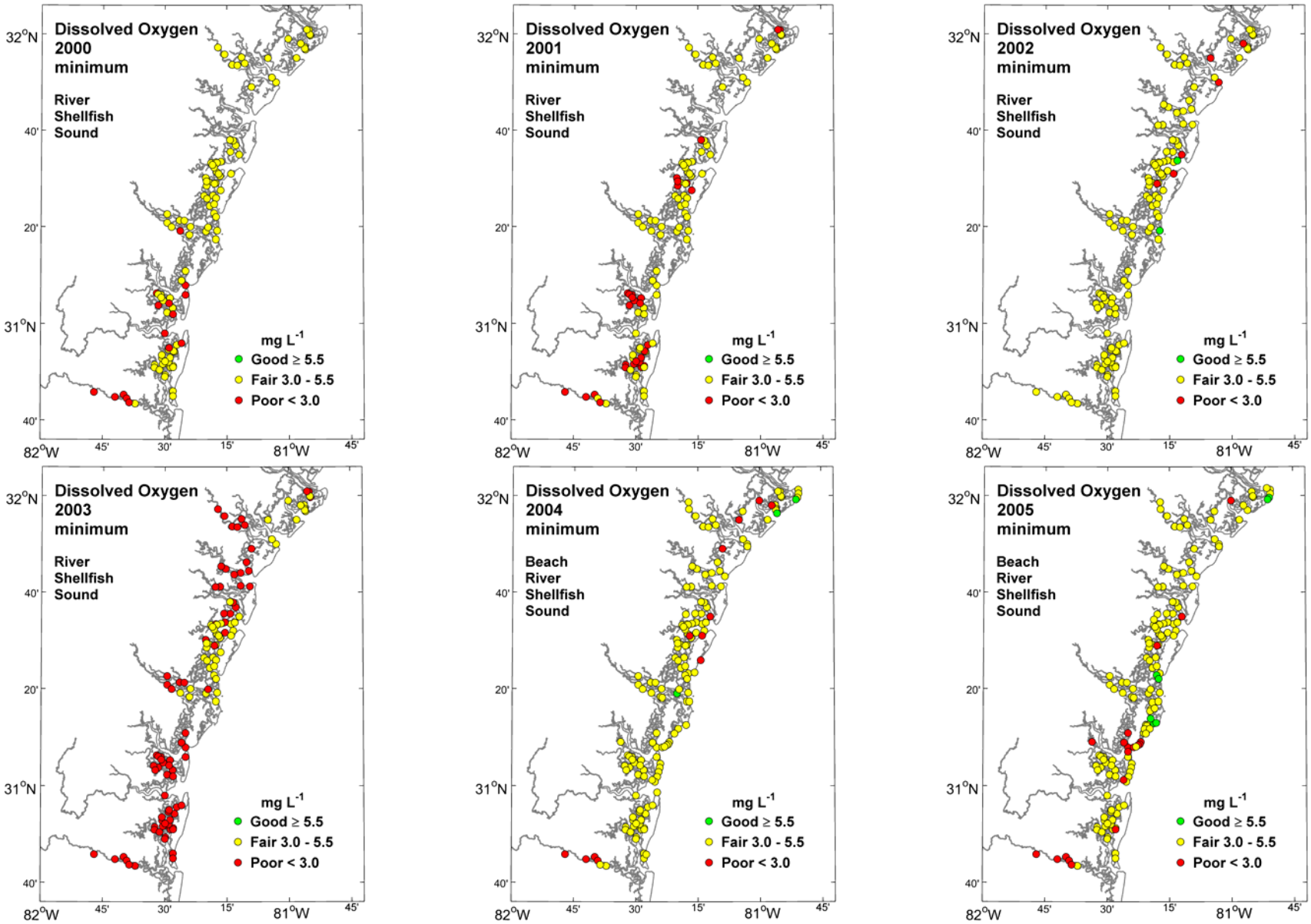
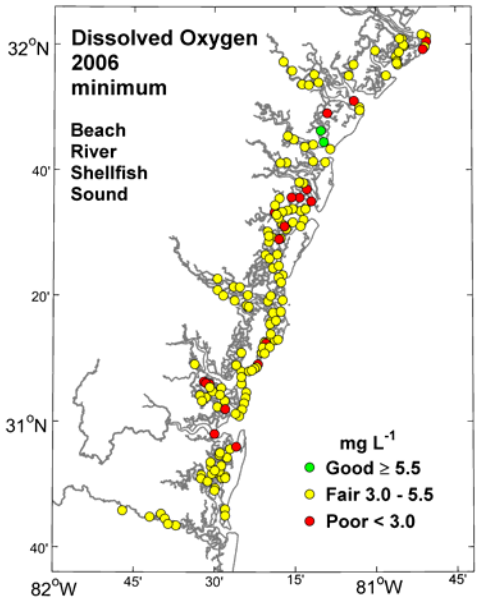
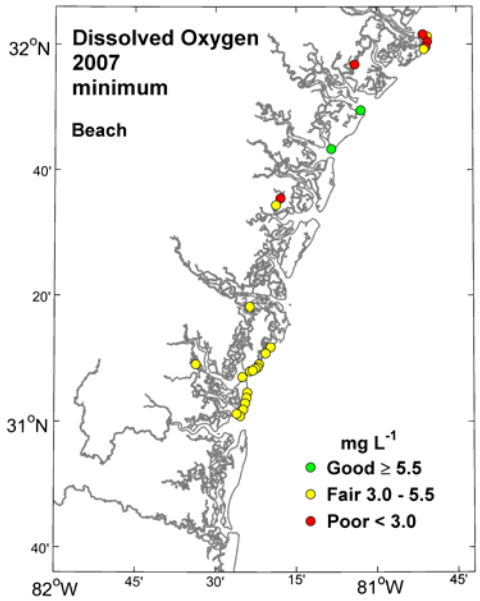


Figure 6-3. Annual minimum dissolved oxygen status at sites sampled by GA DNR CRD during 2000-2008 for programs noted on maps.





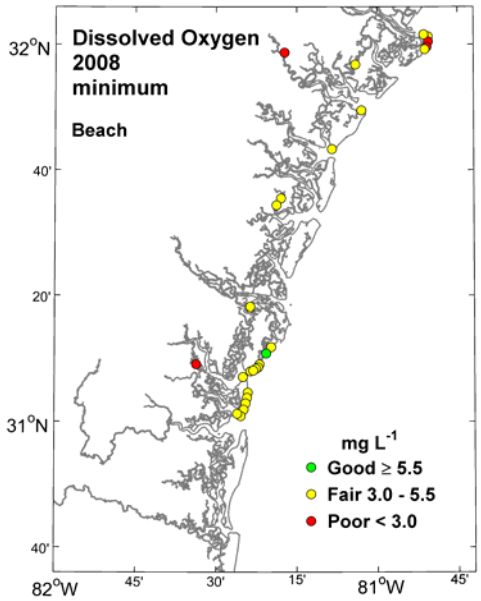


Figure 6-3 continued.

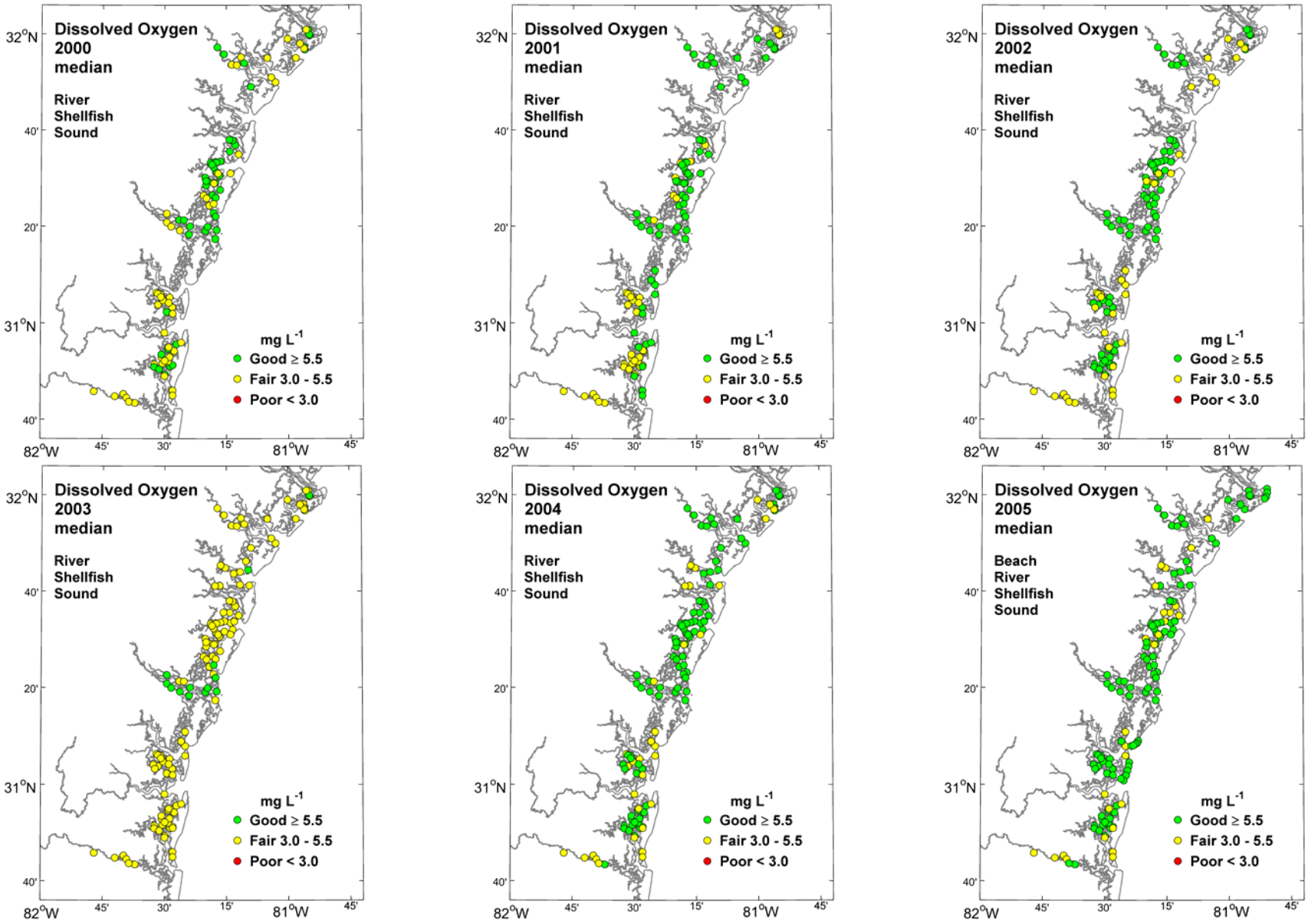
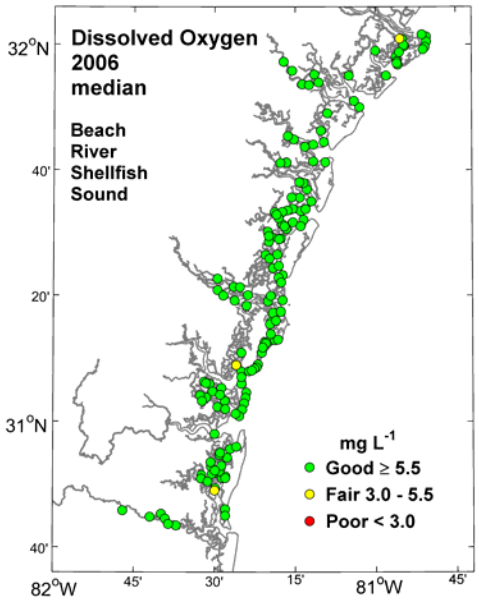
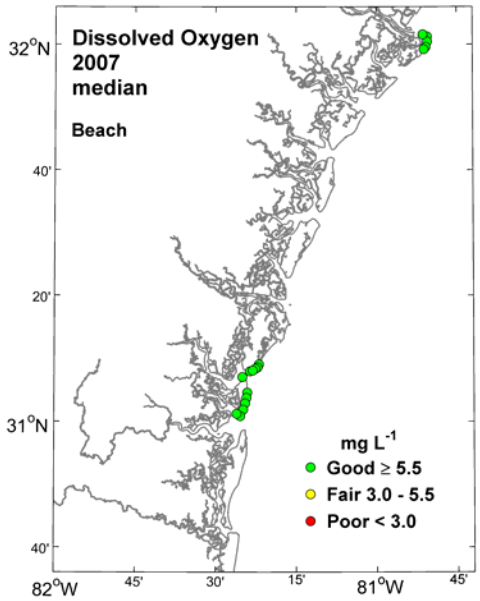


Figure 6-4. Annual median dissolved oxygen status at sites sampled by GA DNR CRD during 2000-2008 for programs noted on maps.





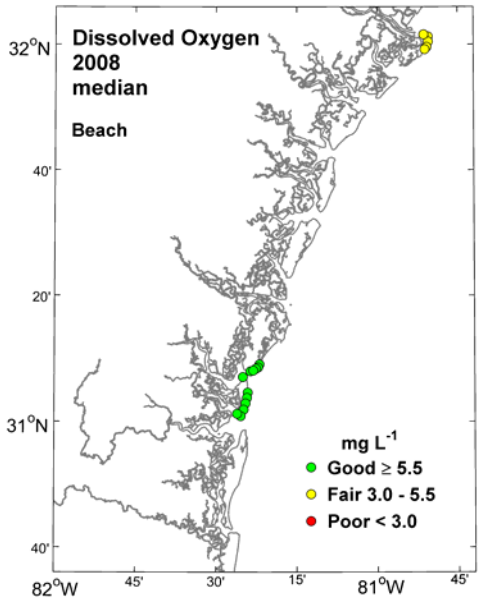


Figure 6-4 continued.

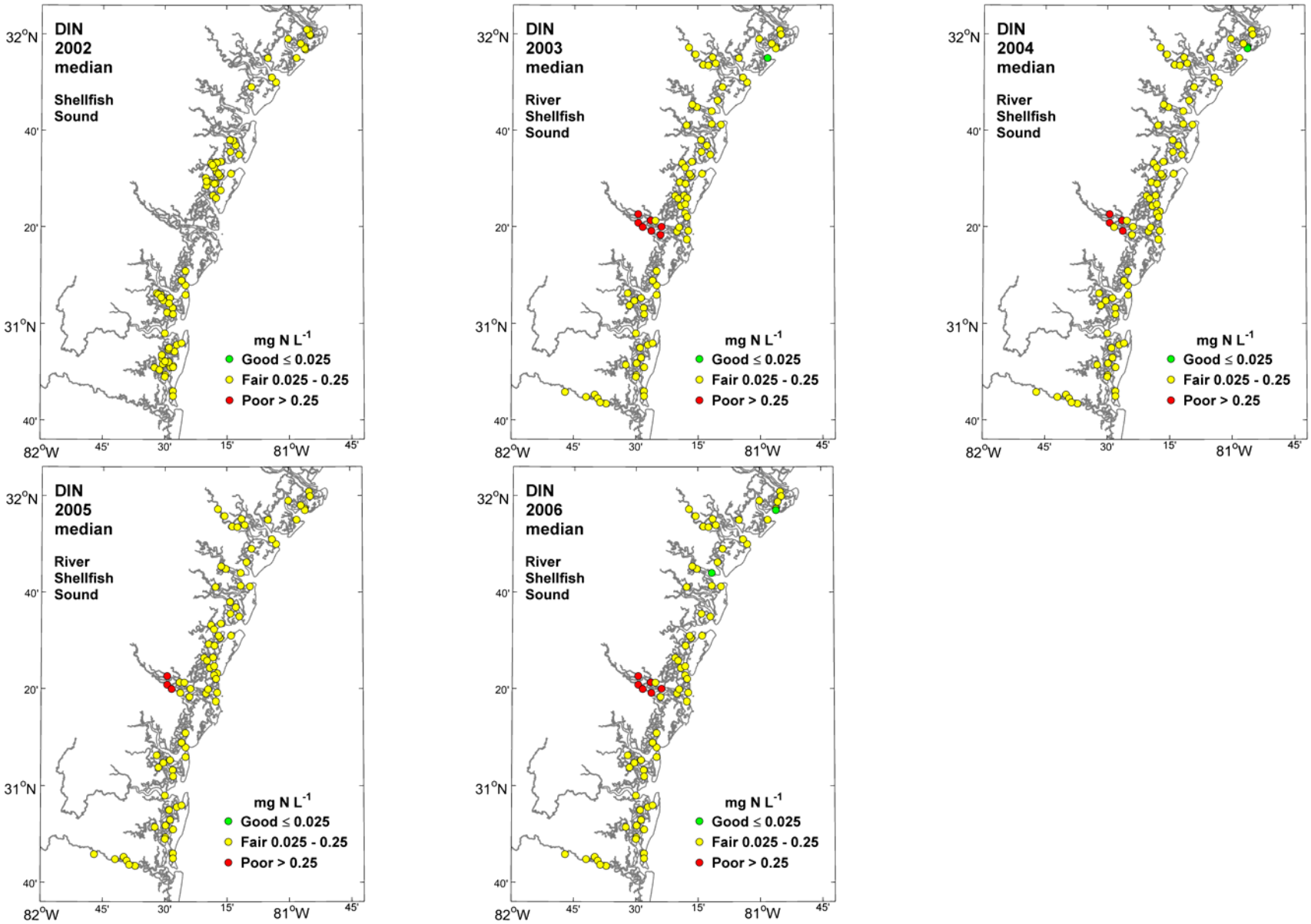


Figure 6-5. Annual median nitrogen status (using DIN) at sites sampled by GA DNR CRD during 2002-2006 for programs noted on maps.

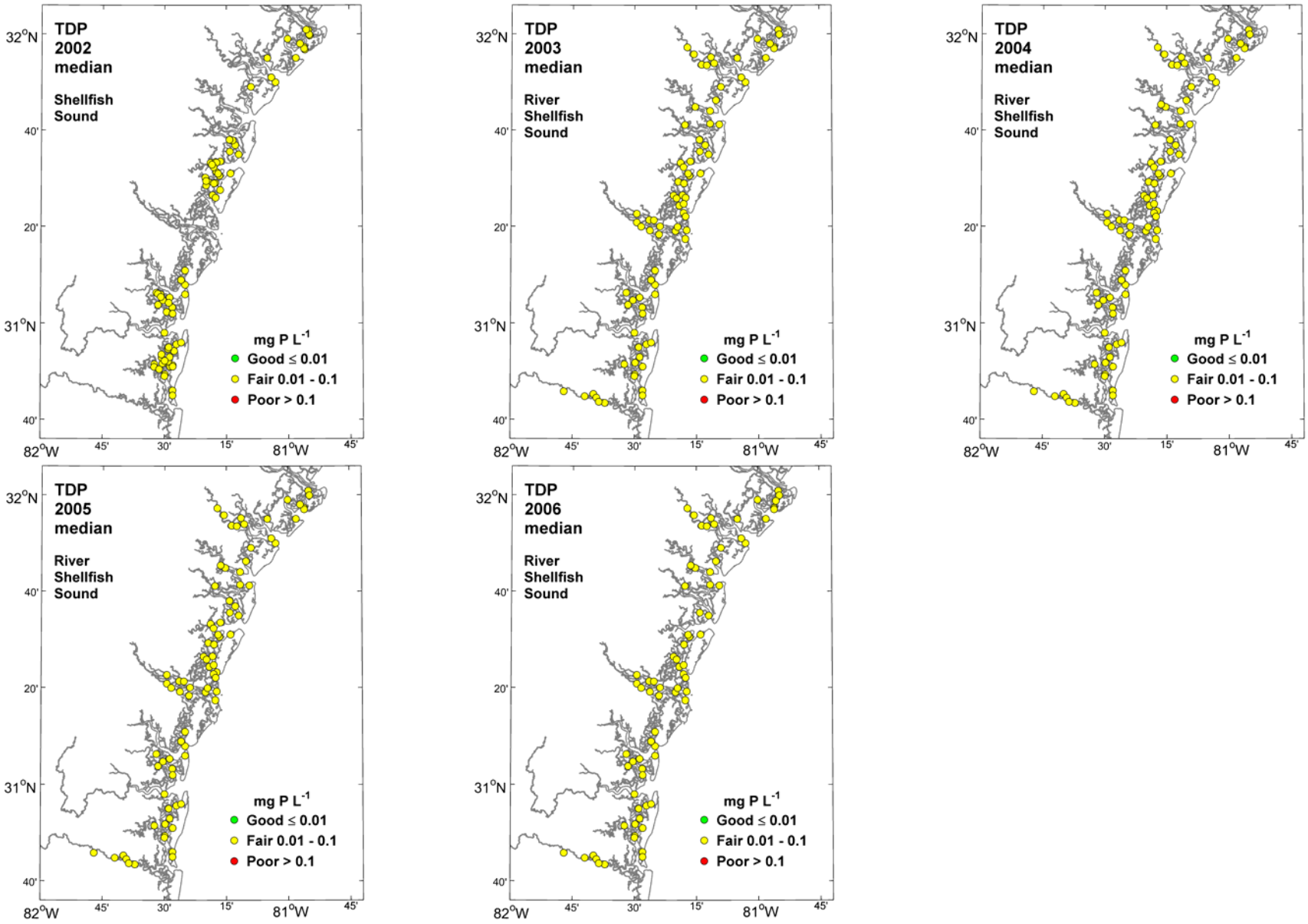


Figure 6-6. Annual median total dissolved phosphorus status at sites sampled by GA DNR CRD during 2002-2006 for programs noted on maps.