A multi-indicator assessment of stream health in southern California

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Introduction

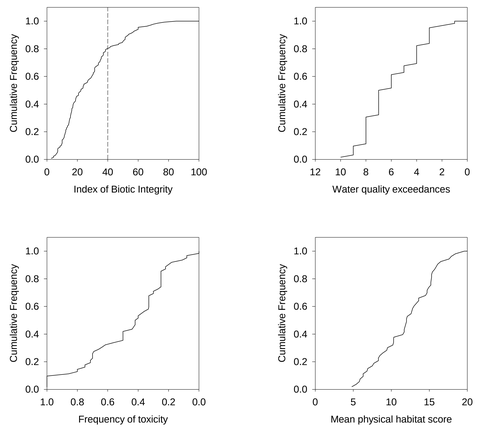
Watershed managers require regional data to develop biomonitoring tools and contextualize local assessments. However, they often rely on data generated by programs with a more local emphasis, such as studies mandated by pollution discharge permits. These programs typically focus on only specific sites or stream reaches, The goal of this study was to compile individual data sets from site-specific programs to see if they could be merged into a regional-scale program. The compiled data was used to address three objectives: 1) perform a regional assessment of stream health in southern California; 2) identify potential stressors to aquatic life in these streams; and 3) how can existing programs be modified to better address the first two questions.

Materials and Methods

Water quality, toxicity, physical habitat, and benthic macroinvertebrate samples were collected from over 140 sites in coastal watersheds in San Diego, Riverside, and Orange counties by six different programs, including the State's Surface Water Ambient Monitoring Program (SWAMP), California Department of Fish and Game, and multiple National Pollutant Discharge Elimination System (NPDES) monitoring programs. Watershed health was assessed by comparing each indicator to applicable thresholds. Scatterplots and multivariate ordinations were used to examine relationships among potential stressors and benthic macroinvertebrate communities.

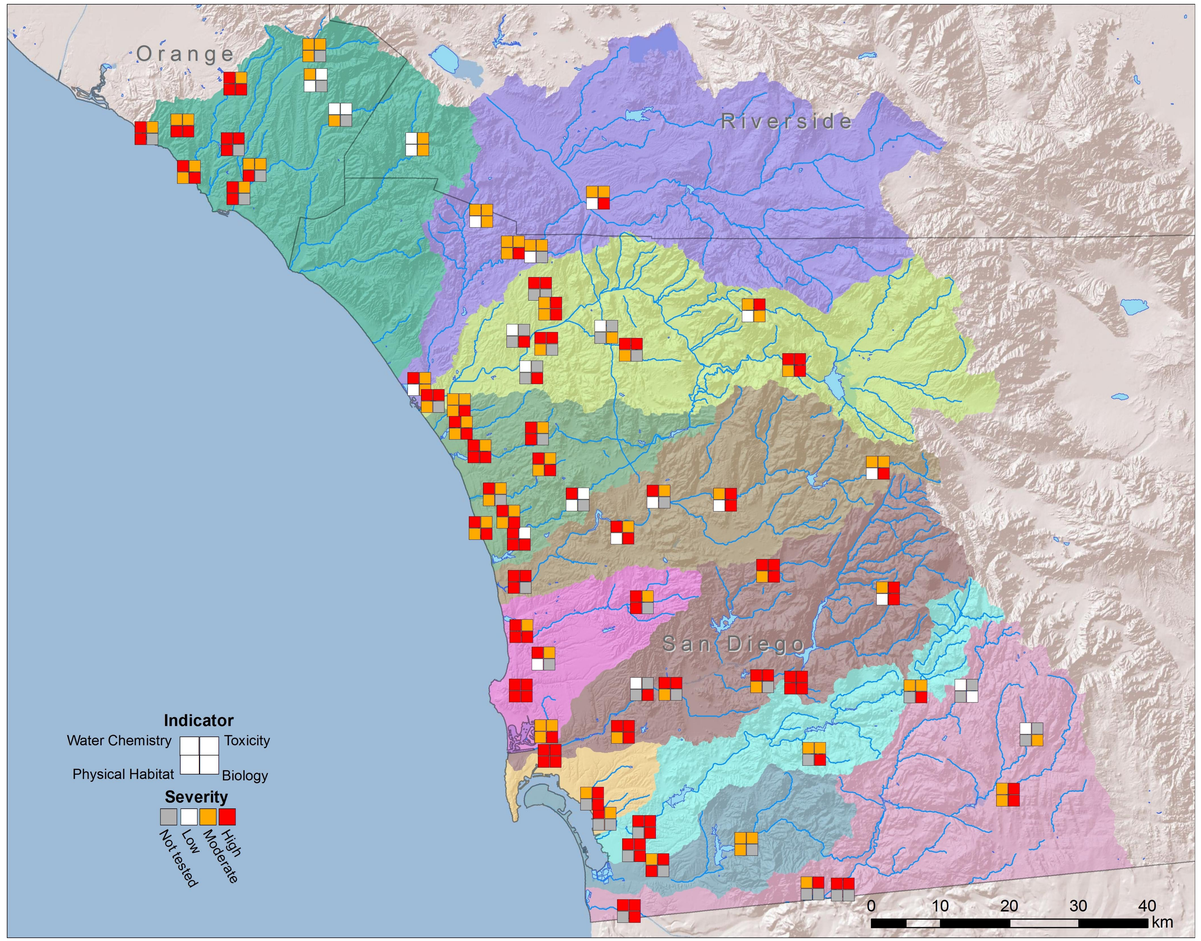
Water chemistry was assessed for nutrients, metals, organic constituents, and conventional parameters; each constituent was compared to applicable thresholds for aquatic life uses. Toxicity was assessed using chronic endpoints for the crustaceans *Ceriodaphnia dubia* and *Hyalella azteca,* and the alga *Selenastrum capricornutum*, and calculating the average frequency of toxicity. Biology was assessed by sampling benthic macroinvertebrates and calculating the Index of Biotic Integrity (IBI). Physical habitat was assessed using the mean score for ten parameters, which were qualitatively scored on a scale of 0-20.

Results



Cumulative frequency distributions show that impacts were widespread for all indicators. In all plots, the right side of the x-axis indicates better condition. The IBI had the steepest curve, indicating that impacts to biology were more widespread than to other indicators. The vertical dashed line marks the threshold (40) between poor and fair condition. Eighty percent of the samples were in poor or very poor biological condition.

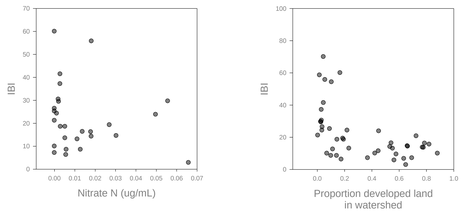
Stream health in the San Diego Region



Multiple lines of evidence suggested that many sites in the San Diego region were in poor condition. For example, over half of all water samples exceeded applicable aquatic life thresholds for multiple water chemistry constituents, such as Ammonia-N, Selenium, specific conductivity, or Sulfate. Water or sediment toxicity was evident in the majority of samples; toxicity to the alga *Selenastrum capricornutum* was the most widespread affecting 59% of all samples. Impacts to benthic macroinvertebrate communities were particularly prevalent, with 80% of over 700 bioassessment samples in poor or very poor condition. Good bioassessment condition was never observed at 87 of the 144 (60%) sites assessed.

In general, water chemistry, physical habitat, and biological indicators showed a similar geographical pattern, with sites along the coast in poor condition, and sites in the interior in better condition. Toxicity was most frequent at sites in southern Orange County and around San Diego Bay. Overall, the best sites were found in the upper portions of the Tijuana, Sweetwater, San Diego, San Dieguito, San Luis Rey, and Santa Margarita Watersheds, as well as in portions of San Juan, San Onofre, and San Mateo Creeks.

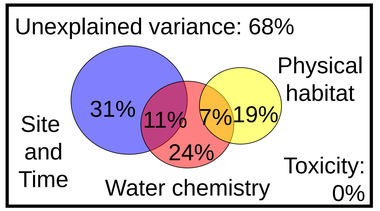
Which stressors are associated with poor biology?



Analysis of the San Diego data showed that many stressors were correlated with low IBI scores. Many showed a threshold relationship. For example, sites with Nitrate-N over 0.2 ug·mL^{-1} were invariably in poor condition.

The strongest relationships were observed for landscape variables. For example, sites in fair or good condition were only observed in watersheds with less than twenty percent developed land.

In order to determine which of these stressors had the greatest influence on benthic community structure, a partial canonical correspondence analysis (pCCA) was performed using a subset of data from Orange County, where all data were collected synoptically. This procedure determines how much variability in community structure was explained by variability in one set of environmental variables when other variables are held constant. We looked at water chemistry, toxicity, and physical habitat, as well as site and time (site location and season of sampling).



Less than a third of the variance could be explained by the measured variables. Unmeasured natural variability and anthropogenic disturbance—included in future SWAMP protocols—may account for additional variance.

Site and time (site location and season of sampling) explained more than other variable types, but water chemistry and physical habitat both explained large portions of the variance. However, toxicity explained none.

Interactions terms were small but significant. Only water chemistry interacted with other types of variables.

Limitations

Data combined from multiple programs were collected at different times and places, and measured different constituents, limiting the ability to associate stressors with degraded biology.

The use of targeted sites allowed assessment of only targeted reaches. A probabilistic design is required for a valid assessment of the entire region.

Conclusions and Recommendations

Sites with undeveloped watersheds were in better condition than developed sites, and often for multiple indicators. Poor biology was strongly associated with degraded water chemistry and physical habitat, but the role for toxicity is less clear.

Future monitoring through a coordinated regional program by the Stormwater Monitoring Coalition will improve regional assessments and stressor identification. This program will ensure synoptic measurement of many indicators at a large number of sites selected in a probabilistic design. This program will begin in Spring of 2009.