A Central Coast Water Quality Report Card For Healthy Watersheds

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David M. Paradies, Central Coast Ambient Monitoring Program
Dr. John W. Hunt, U.C. Davis and CCAMP
What do water quality managers and decision-makers need from their data?

- Where is the problem?
- What is causing the problem?
- What land uses are associated with the problem?
- Where are our best places, that need to be protected?
- Where are places that could be enhanced or improved?
- Are things getting better or worse? Where??
We can answer these types of questions in an assessment report.

But can we answer them with an online tool that updates as the data does??
### Aquatic Life Grades for Waterbodies in the Santa Cruz Watershed

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<tr>
<th>Waterbody</th>
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<tbody>
<tr>
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<td>B</td>
<td>89</td>
</tr>
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<td>B</td>
<td>85</td>
</tr>
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<td>92</td>
</tr>
<tr>
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<td>D</td>
<td>61</td>
</tr>
<tr>
<td>Kings Creek</td>
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<td></td>
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<td>Lompico Creek</td>
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<td>Santa Cruz Harbor</td>
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</tr>
</tbody>
</table>

*In the near future this map will change as you navigate this site.*

**Grades:**
- **A+** Outstanding
- **A** Excellent
- **B** Good
- **C** Fair
- **D** Impacted
- **F** Severely Impacted

### Gazos Creek Lagoon at Hwy 1 (304GAZ)

<table>
<thead>
<tr>
<th>Aquatic Life</th>
<th>Conventional Analytes</th>
<th>Biostimulation</th>
<th>Benthics</th>
<th>Toxicity</th>
<th>Metals</th>
<th>Organic Chemicals</th>
<th>Hydrocarbons</th>
</tr>
</thead>
<tbody>
<tr>
<td>D (61)</td>
<td>95</td>
<td>88</td>
<td></td>
<td>79</td>
<td>23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Human Health**

<table>
<thead>
<tr>
<th>Nitrogen Species</th>
<th>Salts</th>
<th>Pathogens</th>
<th>Metals</th>
<th>Organic Chemicals</th>
<th>Hydrocarbons</th>
<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Auto text is incomplete. Let’s explore drill down table work first. Also, syntax handlers (e.g., plural-singular, good site bad site) are not yet implemented.

The Aquatic Health Grade of D (61) was based on scoring of ***a_analyte_aquatic_life_analytes and ***n_samples individual tests. 0 conventional analytes were in poor or very poor condition. Other conventional analytes scored fair or better, with 9 in excellent or good condition. Of ***25 organic chemicals tested in water or sediment, ***5 were detected and ***2 scored poor or very poor; these were diazinon in water (2 samples) and chlorpyrifos in sediment (3 samples). No samples were collected for hydrocarbons. Of ***6 metals tested in water or sediment, ***6 were detected and ***2 scored poor or very poor; these were copper (3 total samples) and arsenic (3 samples). Benthic invertebrates scored ***D, and toxicity scored C overall, with ***invertebrates in sediments scoring lowest.*

The Human Health Grade of A (96) was based on scoring of nitrogen and pathogen indicators in surface water only. Groundwater is not assessed at the level of the site. Nitrate scored ***C and exceeded the drinking water standard in ***4 of ***53 samples. Pathogen indicators scored ***3 when evaluated relative to water body contact thresholds. ***3 analytes showed increasing concentrations over time; these include ***chlorophyll a and ***pH. No trends in loads were detected.
Our Vision for the Central Coast...

Healthy Watersheds

By 2025:

**Healthy Aquatic Habitat** - 80% of aquatic habitat is healthy; remaining 20% exhibit positive trends in key parameters

**Proper Land Management** - 80% of land is managed to maintain proper watershed functions; remaining 20% exhibit positive trends in key parameters

**Clean Groundwater** - 80 percent of ground water is clean, and the remaining 20 percent will exhibit positive trends in key parameters
To assess our goals we needed to characterize both status (health) and change

- Multi-metric approach
- Measured and modeled data
- Consistent, threshold-based scoring approach
- Status and change at different scales
  - Analyte and multi-metric scales
  - Site, waterbody, and watershed scales
General principles

- Help the user answer Where, Why, What?
- Data from readily available online sources
- Data of documented quality
- Transparency of methods
- Drill down for detail
- Staff-maintained technical content via wikis
Healthy Watersheds Web Report Card, publicly available later this year
Aquatic Life Health Grades for Central Coast Watersheds

- Santa Cruz-304
- Pajaro River-305
- Elhorn Slough-306
- Carmel River-307
- Big Sur-308
- Salinas River-309
- San Luis Obispo-310
- Carrizo Plain-311
- Santa Maria River-312
- San Antonio River-313
- Santa Ynez River-314

Sturgeon Generals Warning: this web app is a very rough work in progress version.

Grades: ● = A+ Outstanding, ● = A Excellent, ● = B Good, ● = C Fair, ● = D Impacted, ● = F Severely Impacted

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Aquatic Life Health Grades for Sites in the wb_id_280

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<tr>
<td>304GAZ</td>
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<tr>
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<th>Pathogens</th>
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<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (96)</td>
<td>98</td>
<td>85</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Gazos Creek Lagoon at Hwy 1 (304GAZ)

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Matrix</th>
<th>Min</th>
<th>Mean</th>
<th>Max</th>
<th># Samples</th>
<th>Grade</th>
<th>Score</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorfenviphos</td>
<td>ug/l</td>
<td>water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>A</td>
<td>100</td>
<td>0.028</td>
</tr>
<tr>
<td>Coumaphos</td>
<td>ug/l</td>
<td>water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>A</td>
<td>100</td>
<td>0.0074</td>
</tr>
<tr>
<td>DDT, total</td>
<td>ug/kg dw sediment</td>
<td>13.1</td>
<td>13.1</td>
<td>13.1</td>
<td>1</td>
<td>F</td>
<td></td>
<td>3</td>
<td>5.28</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>ug/kg dw sediment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>A</td>
<td>100</td>
<td>2.85</td>
<td></td>
</tr>
<tr>
<td>Methyl Parathion</td>
<td>ug/kg dw sediment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>A</td>
<td>100</td>
<td>15.8</td>
<td></td>
</tr>
</tbody>
</table>

Grades:
- **A** = Outstanding
- **B** = Excellent
- **C** = Good
- **D** = Fair
- **E** = Impacted
- **F** = Severely Impacted

### Aquatic Life at Gazos Creek Lagoon at Hwy 1 (304GAZ)

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<td>92</td>
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<tbody>
<tr>
<td>B (89)</td>
<td>99</td>
<td>72</td>
<td>83</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Report Card will connect to CCAMP Data Navigator to access data, maps, graphs, summary stats, trend analysis and other statistical tools.
### Change analysis at San Simeon Creek

**Unusual events (outliers) shown in red**

**Assessment excluding unusual events**

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Change</th>
<th>Trend</th>
<th>Date of Change</th>
<th>Before</th>
<th>After</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia as N, Total-load (NH3_N_LOAD)</td>
<td>mg/l</td>
<td>Increasing</td>
<td>Decreasing</td>
<td>Dec 06 2004</td>
<td>12.1</td>
<td>23.6</td>
<td>95%</td>
</tr>
<tr>
<td>Boron, dissolved (BORON_DIS)</td>
<td>mg/l</td>
<td>Increasing</td>
<td>No trend</td>
<td>May 14 2013</td>
<td>0.28</td>
<td>0.36</td>
<td>29%</td>
</tr>
<tr>
<td>Chloride (CHLORIDE)</td>
<td>mg/l</td>
<td>Increasing</td>
<td>Increasing</td>
<td>Mar 28 2012</td>
<td>95</td>
<td>161</td>
<td>69%</td>
</tr>
<tr>
<td>Chlorophyll a (CHLORA)</td>
<td>µg/l</td>
<td>Increasing</td>
<td>Increasing</td>
<td>Apr 09 2009</td>
<td>2.1</td>
<td>3.2</td>
<td>52%</td>
</tr>
<tr>
<td>Chlorophyll a-load (CHLORA_LOAD)</td>
<td>µg/l</td>
<td>Decreasing</td>
<td>Increasing</td>
<td>Feb 01 2011</td>
<td>3765</td>
<td>929</td>
<td>-75%</td>
</tr>
<tr>
<td>Coliform, ecoli-load (ECOLI_LOAD)</td>
<td>mpn/100 ml</td>
<td>No change</td>
<td>Decreasing</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Coliform, fcoli-load (FCOLI_LOAD)</td>
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Digging into the details...
Setting Chemical Thresholds in Sediment and Water
Our system is designed to allow selection of different thresholds for different purposes
Threshold Selection

- Various sources
  - Marshack (2014) water quality goals
  - US EPA Aquatic life benchmarks
  - New USGS health-based screening levels
  - Canadian Water Quality Goals
  - Scientific literature

- Tiered selection criteria
  - Adopted standards
  - Recommended guidelines
  - Scientific literature

- Software supported threshold selection
Threshold selections and underlying algorithms have been peer reviewed by several experts and are currently being finalized.
We are also designating Outstanding (A+) for “Blue Water Streams” that score Excellent across all measures.
Indices of Health

Human Health Index
- Drinking water
  - Nitrogen species
  - Salts
  - Metals
  - Organic Chemicals
- Water Contact
  - Pathogens

Aquatic Life Index
- Conventional Analytes
- Toxicity
- Bioassessment
- Biostimulatory Risk
- Metals
- Organic Chemicals
Aquatic Life Index

Conventional water quality
- pH departure
- Water temperature
- Nitrate - N
- Total and unionized ammonia
- Orthophosphate - P
- Total suspended solids
- Turbidity

Pesticides and other Organics
- sediment and water

Metals
- sediment and water

Biostimulation
- Oxygen departure
- Chlorophyll a (ug/L)
- % floating mats
- NNE oxygen deficit
- NNE predicted benthic chlorophyll biomass

Toxicity
- Algal cell growth
- Fish survival
- Fish growth
- Invert survival in water
- Invert reproduction in water
- Invert survival in sediment
Habitat Scoring (future)

- Regionally-scaled riparian assessment using imagery analysis in combination with field measures (Central Coast Wetlands Group)
- Physical habitat measures from bioassessment sampling
- CRAM

Biology
- Benthic invertebrates
- Algae
- Other biological measures as available
Human Health Index

**DRINKING WATER**

**Nitrogen Species**
- Nitrate
- Ammonia
- Nitrite

**Salts**
- Boron
- Chloride
- Sodium
- TDS

**Pesticides and other Organics**
- Sediment and water

**WATER CONTACT**

**Pathogens**
- *E. coli*
- Fecal coliform

**Metals**
- Sediment and water
Aggregating scores into an sub-index

Different combining approaches are used for different types of parameters

- Mean average
- Harmonic Mean
- Worst score
### Central Coast Ambient Monitoring Program

#### CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

**CENTRAL COAST REGIONAL WATER QUALITY CONTROL BOARD**

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**Analyte**  | **Units**  | **Matrix** | **Min** | **Mean** | **Max** | **# Samples** | **Grade** | **Score** | **Threshold**
---|---|---|---|---|---|---|---|---|---
Oxygen, Dissolved-departure | mg/l | water | 0 | 0.19 | 1.33 | 494 | C | 76 | 0.5
Water Temperature-departure | degrees C | water | 0 | 0 | 0 | 493 | A | 100 | 3
Ammonia as N, Unionsized | mg/l | water | 0.0001 | 0.002 | 0.04 | 107 | A | 95 | 0.025
Ammonia as N, Total | mg/l | water | 0.01 | 0.05 | 0.36 | 124 | A | 95 | 0.49
Nitrate, Nitrite as N | mg/l | water | 0.42 | 2.55 | 7.83 | 125 | F | 14 | 1
OrthoPhosphate as P | mg/l | water | 0.15 | 0.41 | 1.06 | 125 | F | 11 | 0.13
pH departure | -log[10^+] | water | 0 | 0.002 | 0.7 | 492 | A | 99 | 0.1
Suspended Solids, Total | mg/l | water | 0.5 | 17.7 | 1000 | 245 | A | 96 | 30
Turbidity | ntu | water | 0 | 15.6 | 1490 | 131 | A | 96 | 25

**Grades:**
- **A+** = Outstanding
- **A** = Excellent
- **B** = Good
- **C** = Fair
- **D** = Impacted
- **F** = Severely Impacted

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**Aquatic Life** | **Conventional Analytes** | **Biostimulation** | **Benthics** | **Toxicity** | **Metals** | **Organic Chemicals** | **Hydrocarbons**
---|---|---|---|---|---|---|---
F (43) | 68 | 87 | 17 | | | |

**Human Health** | **Nitrogen Species** | **Salts** | **Pathogens** | **Metals** | **Organic Chemicals** | **Hydrocarbons** | **Groundwater**
---|---|---|---|---|---|---|---
B (81) | 86 | 66 | 79 | | | |

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*Terms and conditions apply.*
Scoring Change
Why is this important?

For our region, it allows us to address the change component in our Vision goals:

**Healthy Aquatic Habitat** - 80% of aquatic habitat is healthy; remaining 20% exhibit positive trends in key parameters
From our website: Nitrate in the Monterey Area
From our website: Nitrate in the Monterey Area
From our website: Nitrate in the Monterey Area (note arrow icons denoting change).
We look at change in two ways:

Kendall Trend Analysis
We look at change in two ways:

Kendall Trend Analysis
Some change doesn’t fit a straight line:
Some change doesn’t fit a straight line:
Some change doesn’t fit a straight line:
Change Point Analysis defines probable change points in a time series of data.

In this case, a treatment plant upgrade went online in May, 2007.
Apply scoring to data on each side of Change Point to grade (color) two sections of arrow icon
Scoring whole watersheds

(currenly in progress)
• Assign scores to upstream reaches.
• Use modeled data to score unmonitored areas
Modeled data from California’s recent Healthy Watersheds (CADMUS) Assessment

Relative Watershed Condition Index

- Percent Natural Land Cover
- Percent Intact Active River Area
- Sedimentation Risk
- Percent Artificial Drainage Area
- Dam Storage Ratio
- Road Crossing Density

Screening level assessment results from California Integrated Assessment of Watershed Health (The CDM Group, 2013)
Scoring Reaches

NHD reach network allows site scores to travel upstream to next site or a land use boundary.
Next Steps

- Public release of Data Navigator in September.
- Methods manual to the SWAMP program for peer review this fall.
- Public release of Phase 1 of the Central Coast Healthy Watersheds Report Card this winter
Phase 2 of the Healthy Watersheds Report Card

• Add linked groundwater data from GeoTracker to Human Health Goal

• Address Goal 2 related to watershed function and land management
  • Pesticide applications
  • Impervious surfaces
  • Ag program metrics
  • Stormwater program metrics
  • etc.
Adoption of our software in a state-wide framework?

• Software is open source and is available for use by others
• We have provided Moss Landing Regional Data Center with Regional versions of the Data Navigator
• State Board has expressed interest in adopting Data Navigator for broader use in association with CEDEN
• The Council’s Healthy Streams workgroup has expressed interest in adopting the Report Card for broader use in the Healthy Streams web portal
What is CCAMP OpenWater?
CCAMP OpenWater is...

...An Internet-based **Open Source Software Toolkit** focused on water quality and quantity assessment and visualization.

- Multi-server environment
- Scheduled data mining from multiple databases
- Data grooming
- Statistical Analysis
- Data visualization tools

"If I can't picture it, I can't understand it." (Albert Einstein)
Why Open Source?

- Reduces system development failure risk
- Provides access to international community of code developers and standards
- Empowers agency staff, users, and development partners
- Avoids pre-committing the State and others to licensing agreements with sole source commercial vendors
The system is intended to use routine automated queries to keep data up-to-date.
Data Grooming

- Synonym dictionaries
- Analyte name standardization
- Units of measurement standardization
- Quality assurance data filtering
- Handling of duplicates
GeoSpatial processing and linking

• Automated linking of monitoring sites to GIS layers
• Handling GIS layer idiosyncrasies
• Linking of land use and other datasets to sites
  • Pesticide use characterization
  • Land Cover characterization
  • Flow and Load estimation
Geospatial Framework

- National Hydrography Dataset Plus
- National Watershed Boundary Dataset
- National Land Cover Dataset
- Public Land Survey System Boundaries
- Bulletin 118 Groundwater Basin Boundaries
- California Healthy Watersheds (CADMUS)