Estimation of reduction of export using DSM2-PTM and PEI

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POD (Pelagic Organism Decline)

- Recent collapse of abundance of pelagic organism
  - Delta Smelt
  - Reasons are still unclear
  - Export of SWP/CVP is considered as a one of possible causes
Wanger Decision

- Issued on Dec 14, 2007
- Reduce pumping to protect Delta Smelt
  - By establishing Old and Middle River flow criteria
- Temporary measures until new Federal Biological Permits are issued
How Much Export Must Be Reduced?

- Finding out the amount of reduction in export to reduce possible particle entrainment is very crucial.

- The best way would be
  - Minimizing entrainment and
  - Maximizing export
Find Out Export Reduction by PEI

- Set a target **PEI** (Potential Entrainment Index)
- What export would meet a target PEI under a given hydrodynamics and particle distribution in the Delta?
  - No analytical solution
  - Solve iteratively by running DSM2-PTM several times
    - An optimization problem
Procedure

Start

Read water volumes

Read particle distribution

Read historical export

Start with an initial guess of export adjustment

Generate an adjusted historical export DSS file

Run DSM2-PTM

Read PTM results

Calculate PEI

Meet PEI target?

Set a new export adjustment rate

No

Yes

End
Implementation

- The procedure requires reading inputs, adjusting export, running DSM2-PTM, reading output, and solving the optimization.
  - Can be scripted by Python
  - VTools to handle DSS files (input and output time series of DSM2-PTM)
  - ‘Brent algorithm’ to solve the optimization
Streamlined Runs

- Combining environmental variables in DSM2 database and python command can control different settings in DSM2-PTM in a batch.

Input file of DSM2

```
DCC_ENV           {DCC_SET}
```

Python code

```
os.environ["DCC_SET"] = 1
```

DSM2 Database

<table>
<thead>
<tr>
<th>La...</th>
<th>Gate</th>
<th>Device</th>
<th>Variable</th>
<th>Input File</th>
<th>Path/Value</th>
<th>Fillin</th>
<th>Use</th>
</tr>
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<td>op_from_nonconstant</td>
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<td>none</td>
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</table>
Application
- Particle Entrainment

- With historical input, Year 2003, late March

\[ PEI = \sum_{i=1}^{N} (PP_i \times RA_i) \]
Application
– Particle Distribution

- Year 2003, late March (1st survey)

\[ PEI = \sum_{i=1}^{N} (PP_i \times RA_i) \]

\[ RA_i = (P_i \times V_i) / \sum_{i=1}^{N} (P_i \times V_i) \]

(From DFG website)
Application - Result

- Year 2003, late March
- Target PEI: 3.27% over 20 days
  - Historical PEI: 14.51%
  - Reduce 67% of historical export to meet the target PEI
    - 345 TAF to 114 TAF over 20 days
Application - Year 2003

Particle Injection Date

Export Over 20 Days (TAF)

Historical
Target 3.27%
PEI
Limitations

- PTM simulates particles.
- Uncertainties and Errors
  - Fish survey, volume, etc.
- Historical distribution is used even though particle distribution under new hydrodynamic conditions can be different.
- Iterative procedure may require considerable computational time.
Conclusions

- Reduction of export under certain hydrodynamic condition and particle distribution can be estimated by PEI and DSM2-PTM.

- Impact on SWP exports while meeting entrainment target can be evaluated with different Delta management strategies, e.g. barriers.
Questions and Suggestions

Kjin Nam (knam@water.ca.gov)
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Potential Entrainment Index (PEI)

- Delta-wide estimation of particle entrainment
  - Weighted-average of entrainment
    \[ PEI = \sum_{i=1}^{N} (PP_i \times RA_i) \]

- \( PEI \): Potential Entrainment Index to export
- \( PP_i \): Percentage of particles entrained from location \( i \) to export
- \( RA_i \): Relative abundance of particles at location \( i \)
  \[ RA_i = \frac{(P_i \times V_i)}{\sum_{i=1}^{N} (P_i \times V_i)} \]

- \( P_i \): Number of particles at location \( i \)
- \( V_i \): Water volume of location \( i \)
- \( N \): Number of locations
PEI Calculator

- Developed by Yiguo Liang
- Derived regression relationships between entrainment and OMR/QWEST at survey stations.
  
  \[ PP_i = f_i(\text{OMR or QWEST}) \]

- Fast and easy to use
- Does not consider different hydrodynamics
An Example of EI Regression

20-Day Cumulative Percent Entrainment to SWP & CVP, Zone 1

Note: Zone 1 includes stations 914, 915, and 918 and entrainment index is weighted average proportional to station-associated volume of water

(From Yiguo Liang’s presentation in 2007)
Adjusting Export

- Open a DSS file for historical setting and retrieve export time series.
- Reduce (or increase) daily export time series by certain percentage.
  - Python scripts (VTools)
  - Check constraint such as pumping capacity
- Save newly-adjusted time series into a new DSS file.
Impact of Wanger Decision

- **Dec 24 ~ Jan 3: Adults**
  - OMR $\geq -2,000$ cfs

- **Winter: Adults**
  - OMR $\geq -5,000$ cfs

- **Winter-Spring: Laval and Juvenile**
  - $-750$ cfs $\geq$ OMR $\geq -5,000$ cfs

- **Lost opportunity to capture Delta Flow in Winter/Spring**
20mm Delta Smelt Survey

- Dept of Fish and Game performs 8~10 annual surveys
  - Every two weeks
  - [http://www.delta.dfg.ca.gov/data/20mm](http://www.delta.dfg.ca.gov/data/20mm)