Surface Conditions Report
September 11, 2013

Ozone sensors on board: Donovan Rafferty, Ecology Air Quality Program (here)

Up-to-date observations of visible water quality conditions in Puget Sound and the Strait of Juan de Fuca
## Marine conditions from 9-11-2013 at a glance

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### Personal flight log

Flying for Ecology’s marine program attracts experienced and engaged float-plane pilots. Joe Leatherman fits the bill like no other. A little visitor sweetened our day (see more).

### Weather conditions

New record temperature of 91 deg F on EOPS flight day. Overall: warm air temperatures, more sunshine in the south, and decreasing river flows during the past week.

### Water column and mooring

After 2 years of colder temperatures and higher oxygen, Puget Sound waters are taking a turn towards lower dissolved oxygen. Or are they?

### Aerial photography

Red-brown blooms in South Sound inlets and San Juans. Large amounts of floating organic material in Hood Canal and Puget Sound inlets. Flows from glacier-fed rivers are visible by the turquoise-colored water. Many fronts seen at the surface in the San Juans.

### Ferry and satellite

Satellite imagery reveals widespread phytoplankton blooms in Whidbey Basin, Hood Canal, and South Puget Sound. Fraser River plume extends across Strait of Georgia!
North Sound Flight with Kenmore Air pilot Joe Leatherman

Want to fly a float plane like Joe? Get a commercial pilot certificate, add 100 hours of flight time, pass written & oral flight tests, add 10 hours of in-plane instructor training, and pass a ride check with an FAA pilot examiner.

Joe was hand-picked by Kenmore Air’s director of operations, Chuck Perry, for our work. Joe is dedicated to our safety and our success. He got the float plane bug after flying to Alaska. EOPS flights include friendship, science, flying skills, environmental curiosity, and knowledge. To learn more: http://www.ecology.com/2013/08/28/healthy-puget-sound/
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<td>JOE ON THE GO:</td>
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<tr>
<td>A. Loading CTD sensors</td>
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<td>B. Installing CTD winch</td>
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<td>C. Flying to stations</td>
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<td>D. Helping with samples</td>
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<td>E. Unloading plane</td>
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Elevated ozone concentrations can occur when sunlight and air temperatures are high. The Air Indicator Report for Public Awareness and Community Tracking (AIRPACT) is a computerized system for predicting air quality that might impact public and environmental health. With high ozone concentrations predicted on Sept. 11, GPS-referenced ozone monitoring equipment joined the flight to compare predicted (AIRPACT) and measured concentrations.

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Comparing predicted and measured ozone levels on 9-11-2013

"Today’s target, ozone hunting!"
Meteorological conditions typically explain up to half of the variance in observed marine variables (Moore et al. 2008), particularly in shallower waters like those of south Puget Sound. I summarized the specific conditions prevalent during the past two weeks, from north to south. Source: [http://www-k12.atmos.washington.edu/k12/grayskies/nw_weather.html](http://www-k12.atmos.washington.edu/k12/grayskies/nw_weather.html)

**Two week summary:**

**Air temperatures:** Daily average air temperatures have increased to mostly above-normal levels.

**Sunshine:** Daily averages frequently have been below normal during the past week as the result of a marine layer.

**River flows** have decreased to near-normal from higher levels after the heavy rain last week. Below normal flow levels exist for the Nooksack.

**Winds** have been weak and variable throughout the region.

We use a chartered float plane to access our monthly monitoring stations most cost effectively.

We communicate data and environmental marine conditions using:

1. Marine Water Condition Index (MWCI)
2. Eyes Over Puget Sound (EOPS)
3. Anomalies and source data
Puget Sound water conditions are changing again! Compared to 2011-2012, when waters were colder and fresher with higher oxygen, stations are showing signs of warmer temperatures and decreasing oxygen. Each pixel is a monthly survey at a single station.
The ocean affects water quality: Ocean Climate Indices

Ocean boundary conditions have been favorable for water quality in Puget Sound: (a) colder water (PDO), (b) less upwelled low oxygen and high nutrient ocean water reaching Puget Sound (Upwelling Index), and (c) higher surface productivity along the coast (NPGO). Where are we heading next?
We observe increasing nutrients and changing algal biomass patterns in Puget Sound.

Red-brown blooms in South Sound inlets and San Juans. Large amounts of floating organic material in Hood Canal and Puget Sound inlets. Flows from glacier-fed rivers are visible by the turquoise-colored water containing glacial flour. Many fronts seen at the surface in the San Juans.

**Mixing and Fronts:** Pronounced fronts due to suspended sediment in Rosario Strait, Skagit Bay, the San Juan Islands, and Dana Passage.

**Jellyfish:** Only a few patches seen in Budd Inlet.

**Suspended sediment:** Glacier-fed rivers bring glacial flour to north Puget Sound.

**Visible blooms:**
- **Red brown:** Anacortes marina, West Sound, and Budd, Eld, and Totten inlets.
- **Green:** Sinclair Inlet, Port Susan, Port Angeles, Olympia marina.

**Debris:** Abundant in Case, Budd, and Totten inlets, Dana Passage, Hood Canal, Port Susan, Port Madison, Mukilteo, and Sinclair Inlet.
Aerial photography & navigation guide
Date: 9-11-2013

Flight Information:

Morning flight, photos 1-7:
Good visibility, calm

Afternoon flight, photos 8-20:
Good visibility, calm, hot.

Observation Maps:
- Central Sound & North Sound
- Hood Canal & South Sound
Red-brown blooms, wave structures and organic debris in southern inlets.
Location:  A. Budd Inlet. B. Eld Inlet. C-D. Totten Inlet. (South Sound) 9:19 AM.
Water with high silt content entering into Port Townsend Bay from two sides.
Location: A. Near Port Townsend Canal, B. Port Townsend (Central Sound), 10:01 AM.
A. Surface debris (algal mats). B. Green-yellow and red-brown phytoplankton bloom. Location: Scow Bay in Kilisut Harbor (Indian Island near Port Townsend), 10:00 AM.
Large front delineating sediment-rich water from other water.
Location: Rosario Strait (San Juan Islands), 11:38 AM.
Large-scale mosaic of water masses with different sediment content.
Location: Rosario Strait (San Juan Islands), 11:40 AM.
Strong front and bordering surface water with different sediment content.
Location: Rosario Strait (San Juan Islands), 11:41 AM.
Fraser River sediment traversing and mixing dramatically with water in the San Juan Islands.
Location: Near Obstruction Island (San Juan Islands), 12:15 PM.
Fraser River sediment traversing and mixing with water in the San Juan Islands.

Location: Orcas Island (San Juan Islands), 12:23 PM.
Red-brown bloom in West Sound and sediment-rich water.
Location: Orcas Island (San Juan Islands), 12:24 PM.
Red-brown bloom in West Sound and Massacre Bay.
Location: Orcas Island (San Juan Islands), 12:24 PM.
Fraser River plume and front with debris originating out of Rosario Strait.
Location: North of Rosario Strait (Georgia Basin), 1:35 PM.
Large-scale eddies with different sediment and algal content.
Location: Northwest of Lummi Island (San Juan Islands), 1:36 PM.
Intense red-brown bloom in Cap Sante Marina and sediment in water near barge.

Location: Anacortes Harbor (Anacortes), 2:19 PM.
Distinctly different water separated by dike: Swinomish Channel and Skagit glacier-fed water
Location: Near La Conner (Skagit Bay), 2:26 PM.
Aerial photography 9-11-2013

| Flight log | Weather | Water column | Aerial photos | Ferry and Satellite | Moorings |

Narrow band of Skagit river plume rich in glacial silt hugging the western shore of Skagit Bay.

Location: Skagit River estuary near Dugualla Bay (Skagit Bay), 2:27 PM.
Green phytoplankton bloom meeting plume of Stillaguamish River with debris line.
Location: Triangle Cove (Port Susan), 2:54 PM.
Location: A-C. Central Sound, D. South Sound, 5:10 PM.
A. Red-brown algae bloom and organic surface debris. B. Debris in Pickering Passage.
Location: Between Harstine and Squaxin Island. (South Sound), 5:31PM.
**Red-brown algae bloom and abundant surface debris outlining front.**

Location: Dana Passage (South Sound), 5:32 PM.
Red-brown algae bloom and long organic debris lines.
Location: Budd Inlet (South Sound), 5:35 PM.
Aerial photography observations in Central Sound

Date: 9-11-2013

Central Sound

Numbers on map refer to picture numbers for spatial reference
Aerial photography observations in Central Sound

Date: 9-11-2013

Hood Canal

South Sound
Legend to map annotations

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<th>Plumes</th>
<th>Blooms</th>
<th>Debris</th>
<th>Front</th>
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<tr>
<td>• Freshwater with sediment solid</td>
<td>• Dispersed</td>
<td>• Dispersed</td>
<td>• Distinct water mass boundaries</td>
</tr>
<tr>
<td>• Freshwater with sediment dispersed</td>
<td>• Solid</td>
<td>• Solid</td>
<td>• Several scattered</td>
</tr>
<tr>
<td>• Coastal erosion with sediment</td>
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Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

Debris:
Debris can be distinguished into natural and anthropogenic debris floating at the surface sensu Moore and Allen (2000). The majority of organic debris in Puget Sound is natural mixed with discarded man-made pieces of plastic, wood, etc. From the plane, we cannot differentiate the quality of debris at the surface and therefore, call it for reasons of practicality just “debris”.

No Victoria Clipper data available – Hardware upgrades in progress!!!

Current Conditions:
MODIS-Aqua continues to provide valuable near-surface imagery of key water quality parameters throughout greater Puget Sound. Widespread phytoplankton blooms seen in Whidbey Basin, Hood Canal and South Puget Sound. Fraser River plume extends across Strait of Georgia!

MERIS True Color image used for spatial context (19 February 2011) of the Victoria Clipper en route monitoring route (red dashes on map).
Satellite imagery reveals synoptic view of river plumes, phytoplankton blooms, and mud flats!

Widespread phytoplankton blooms observed in Whidbey Basin, Hood Canal, and South Puget Sound. Fraser River plume extends across Strait of Georgia.
Strength through collaboration across agencies, academic institutions and companies. We have plans to continue to collect data at our Admiralty Reach (UW Applied Physics Lab) and Mukilteo (ORCA College) moorings into the future. Operations at all other mooring locations have been suspended in order to reallocate existing resources.

Note: Due to state and federal budget reductions, our mooring program is being downscaled. We are now focusing on measuring ocean intrusions!

We are now focusing on measuring ocean intrusions!

Why? The importance of the ocean on water quality in Puget Sound is being emphasized by Ecology’s mooring at Admiralty Reach, long term monitoring data, modeling studies, and academic publications. Admiralty Reach is a challenge - it requires a team effort!

Upwelling along the coast can bring high nutrient, low oxygen and low pH ocean water into Puget Sound. Such intrusions explain much of the year to year variability in water quality.

For intrusions to enter Puget Sound, several conditions have to align:

- **Prolonged upwelling** along the Washington coast. *Driver: Northerly winds*
- **Estuarine circulation moving dense water from the coast** into the Strait of Juan de Fuca. *Driver: High Fraser River flow during summer*
- **Neap-Spring tide phase and character** favorable to intrusions along the 30 km length of Admiralty Reach. *Drivers: Neap tides and tidal harmonics*
Get data from Ecology’s Monitoring Programs

Long–Term Monitoring Network

Access core monitoring data:
http://www.ecy.wa.gov/apps/eap/marinewq/mwdatASET.asp

Ferry track
Morning flight
Evening flight

Real–Time Sensor Network

Freshwater Report:

Access mooring data:
http://www.ecy.wa.gov/programs/eap/mar_wat/-html

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You may subscribe or unsubscribe to the Eyes Over Puget Sound email listserv by going to:
http://listserv.wa.gov/cgi-bin/wa?A0=ECOLOGY-EYES-OVER-PUGET-SOUND

Many thanks to our business partners: Clipper Navigation, Swantown Marina, and Kenmore Air.

We are looking for feedback to improve our products.

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WA Department of Ecology