Phytoplankton and Primary Production
Welcome! While we wait, please:
- Introduce yourself in the chat.

During discussion:
- Add your questions to the chat
- Raise your hand and we’ll unmute you
- Discussion is focusing on the driving questions and associated scientific uncertainties. However, please feel to put in the chat any of the following towards brainstorming the future workshop discussion:
  - Who else should be in the room?
  - The “how” of addressing questions raised using modeling

The slides, recording, and synthesis will be available on Puget Sound Institute’s website
Primary Production & Phytoplankton Breakout
QUESTION 10: Is the ecology of phytoplankton, including nuisance and harmful algal bloom (HAB) species, in Puget Sound well understood?

- BIG GAP: Spatial and temporal resolution of phytoplankton species and abundance.
- The time-scale for changes in phytoplankton abundance is short and spatially variable, requiring more frequent monitoring and in more areas. This applies to both HAB and non-HAB species. For example, shifting between a diatom-dominated food web to microbial-dominated food web (e.g., Noctiluca) has large consequences in reducing the amount of carbon (food) available to higher trophic levels, such as fish and benthic biota.
- Only chlorophyll is monitored regularly for most programs, but conversion to C is too variable to be meaningful for most applications.
- BIG GAP: No phytoplankton rates are being monitored (production, respiration, and sinking)*

2013, 2016 PSEMP Monitoring Gaps Work
Setting the stage: addressing observed changes at the bottom of the food web

Long term changes observed (Ecology’s 27 Stations≈1999 to 2018):

- Silicate:DIN & near-bottom: surface Chl A
- Seasonal changes in Stratification & Chl A
- Seasonal changes in DO, N, salinity & temp

Source: See presentations by Christopher Krembs at Puget Sound General Nutrient Forum, July 19, 2017 and PSEMP phytoplankton group, May 18, 2022 for data plots

What are the impacts and why it matters to marine life and nutrient cycling? - focus of this presentation?

Hypothesis of change under discussion in regional monitoring forums

Vulnerability is largely impacted by ocean and river impacts on physics – a focus of other breakout group today

Opportunity for Modeling<>Modeling
Current Efforts: Complementary Monitoring & Modeling

**Primary Productivity & Phytoplankton Indicator Workshop Series**

*PSEMP Marine Waters Work Group*

5 workshops 2022-2023 to develop:
- State of Knowledge
- Existing Data
- Framework for developing monitoring & future indicators

**Research, Modeling, and Monitoring to Reduce Uncertainties**

Address technical uncertainties & advance modeling tools for decision-making.
- Facilitate scientific workshops and regional collaboration
- Convene Model Evaluation Group
- Lead complementary model runs
- Expand access to models, outputs, tools, and scientific knowledge

Refine Research Actions
## Terms & Definitions

<table>
<thead>
<tr>
<th></th>
<th><strong>Standard Definition</strong></th>
<th><strong>Other Definitions</strong></th>
<th><strong>Typical Units</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phytoplankton</strong></td>
<td>Loose term, includes unicellular autotrophs, mixotrophs and heterotrophs</td>
<td>Only photosynthetic cells (auto/mixotrophs)</td>
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<tr>
<td><strong>Bloom</strong></td>
<td>Loose term, large increase in cell density <em>(Smayda paper)</em></td>
<td>Density above certain threshold (e.g., Chl &gt;30 µg/L)</td>
<td></td>
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<tr>
<td><strong>HAB species</strong></td>
<td>Any species that can have a toxic or harmful effect on other organisms (usually above certain threshold)</td>
<td>Any species that can negatively affect the environment (e.g., toxic algal species)</td>
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<tr>
<td><strong>Biomass</strong></td>
<td>Total dry weight</td>
<td>Carbon content</td>
<td>mg C/m³, pg C/cell</td>
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<tr>
<td><strong>Primary Production</strong></td>
<td>Rate of carbon assimilation (gross and net) – big discussion – agreed a rate</td>
<td></td>
<td>mg C/m³/yr, mg C/m³/yr</td>
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<tr>
<td><strong>Chlorophyll-a</strong></td>
<td>Cell-bound, measured in the lab following some extraction protocol, usually by collecting cells on a filter - discrete water samples - extraction</td>
<td>Proxy for biomass or PP</td>
<td>mg/m³, mg/m³ or µ/L</td>
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<td><strong>Chlorophyll Fluorescence</strong></td>
<td><em>In vivo</em> chlorophyll fluorescence, usually measured <em>in situ</em></td>
<td></td>
<td>RFU (relative units), mg/m³</td>
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*Rate vs. Concentration!*
Phytoplankton Role & Function in Salish Sea Food Web
Observed Changes & Hypotheses of Drivers
Observed Changes & Hypotheses of Drivers

Christopher Krembs, Washington Dept. of Ecology
Questions and Answers
Discussion: Check on priorities moving forward

Next steps at these workshops:
1. Dive deeper on addressing uncertainties in changes observed, and hypothesis identified

Hypothesis of change under discussion in regional monitoring forums, e.g.:
- Climate change and local human contribution to change in physics/euphotic nutrient availability
- Nutrient balance > lower level food webs
- Diatom > microbial food web

What prioritization of different parts of the physics of the system on the availability of nutrients of the euphotic zone would to address some of these hypothesis
Hypothesis: Changes in the lower food web
“Supporting science varies in strength. See last slide for details on each topic”.

**HS-1:** Climate change has the effect of magnifying human nutrient contribution to Puget Sound and shifts the food web in the summer months.

**HS-2:** Changes in the nutrient balance affect the growth conditions of the lower levels of the marine food web.

**HS-3:** In summer, the microbial food web has gained importance relative to the productive, diatom-based food chain.

**HS-4:** The organic particle export to deeper water changed in response to shifts in the lower-trophic levels of the food web.