Plankton

Puget Sound’s primary producers and primary consumers

Relationship between nutrients and Primary productivity in PS

- Do nutrients limit PP in summer?
- Winter?

NO$_3$ vs. salinity at > 50 m across Salish Sea

D. L. Mackas & P. J. Harrison [1997]
Total nitrogen versus salinity in Bellingham Bay, 2010

Phosphorus versus salinity in Bellingham Bay, 2010

Chlorophyll

Dissolved inorganic nitrogen
**Nutrient addition experiments**

Nutrient experiments in Padilla Bay

![Graph showing nutrient addition experiments.](image)

Berhard and Peele 1997

**PP and light**

PP and light

![Graph showing PP and light.](image)

From Newton and Van Voorhis 2002

**Stratification in the Salish Sea**

Stratification rank order:
1. Whidbey Basin
2. Southern Hood Canal
3. Northern Hood Canal
4. South Sound
5. Main Basin
6. Strait of Juan de Fuca

![Graph showing stratification.](image)
Where does nutrient depletion occur?

Places in the Salish Sea where DIN drops to < 7 μM

Nutrients and eutrophication

- 29 of 41 stations susceptible
- 15% show hypoxia (red) and 20% show DO stress
- Most susceptible stations (36%) in South Puget Sound & Kitsap Peninsula
- Implications for development?

Chlorophyll

- Graph showing chlorophyll levels from May 2001 to April 2002

- Data points for Point Wells, Possession Sound, Admiralty Inlet, West Point

- X-axis: Months from Jan 1998 to Apr 2001
- Y-axis: Chlorophyll (mg m⁻²)

- Graph shows peaks in chlorophyll levels in May 2001 and May 2002.
Phytoplankton of Puget Sound: Chain-forming diatoms

- *Skeletonema costatum*
- *Chaetoceros debilis*
- *Chaetoceros convolutus*
- *Thalassiosira*

Phytoplankton of Puget Sound: Chain-forming Diatoms

- *Rhizosolenia*
- *Detonula*
- *Ditylum*
- *Thalassionema*

Phytoplankton of Puget Sound: Solitary Diatoms

- *Cylindrotheca*
- *Coscinodiscus*

Diatom (diploïtic) life cycle

- Frustule: pure silica coated + layer of organic material.
- Parts:
  - hypotheca
  - epitheca

- Minimum size reached
- Auxospore
- Fusion
- Meiosis
- Vegetative cell
- Fertile cell
- Initial cell
- DIPLOID
- HAPLOID
Dinoflagellates

Thecate: possess armored plates
Athecate: lack armored plates

Phytoplankton of Puget Sound: Dinoflagellates

Ceratium fusus
Alexandrium catenella
Protoperidinium divergens
Noctiluca miliaris
Gyrodinium britannicum

Dinoflagellate (haplontic) life cycle

Germination
Vegetative population growth
Gamete formation
Planozygote
Planomeiocyte
Hypnozygote formation
Hypnozygote
Resting cysts
Phytoplankton of Puget Sound: Microflagellates

**Dictyocha**

**Heterosigma agawashio**

**Phaeocystis**

Cyanobacteria

- **major forms**
  - *Synechococcus* (1-3\(\mu\)m)
  - *Prochlorococcus* (~0.5 \(\mu\)m)
  - *Trichodesmium* (1-3\(\mu\)m)

- In Hood Canal: >70% of cells and ~20% spring biomass is *Synechococcus*

Phytoplankton of the main basin

- King County Monitoring program
- 108 types (taxa) identified to genus
  - 60 diatoms, 40 dinoflagellates 8 other flagellates
- **Point Jefferson** (N): *Chaetoceros, Rizosolenia, Skeletonema, Thalasiosira*
- **Quartermaster Harbor**: *Detonula, Coscinodiscus, Thalasionema, But, in summer: Ceratium fusus and Prorocentrum gracile, and Alexandrium catenella*

Zooplankton in Puget Sound

Do grazers control productivity?
Chlorophyll

Calanoid copepods

Predatory copepods

Mysids and Euphausids (krill)
- Easy to identify because they have eyes
- Mysids are smaller (<4mm) with stalked eyes
- Eat copepods
**Saggita the arrow worm**

- Phylum Chaetognatha
- Long-lived (some species more than one year)
- Eat copepods 
  (*Calanus* and *Pseudocalanus*)

**Cnidarians and Ctenophores**

- Cnidarians: Collect prey using stinging cells (cnidocytes)
- Ctenophores: Collect prey using sticky cells (colloblasts) or engulf their prey
- Cnidarian jellies
  - Hydrozoans (juvenile phase)
  - Scyphozoans (adult phase)
  - (*True jelly fish*)

**Microzooplankton**

- Ciliates and Tintinnids
- Relatively small (20-640μm)
- Can consume up to 90% of PP (*Lalli & Parsons, 2001*).
- Feed on; detritus, bacteria, naked flagellates, diatoms, other algae
- Tintinnids blooms linked to diatom blooms
- Eaten by meso and macrozooplankton

**Heterotrophic dinoflagellates**

- *Protoperidinium*
- *Nuctiluca* (and “Red Tide”)
- *Gyrodinium britannicum*
**Noctiluca scintillans “Red Tide”**
- 200-2000um in size,
- not photosynthetic – predatory
- bioluminescent

**Zoea crab larvae**
- Common in spring
- Single spines fore and aft indicate brachyuran (crab) larvae
- Hermit crab larval stages easily misidentified as mysid shrimp

**Is grazing important in Puget Sound?**
- Importance of microzooplankton grazers
  - Numerous
  - Rapid reproduction (can keep up with phytoplankton)
- Method of studying grazing effects
  - Dilution technique
  - Collect water samples to create a dilution series
  - Herbivore dilution allows phytoplankton growth
Dilution experiments

Y-intercept = "infinite dilution"

GROWTH RATE

Net Growth Rate (per time)

Growth equation: \( \frac{dp}{dt} = \mu p - \chi z p \)
\( \frac{dp}{dt} = \mu p - \chi D p = \mu p - gD p \)
Solution: \( t \ln(p(t)/p_0) = \mu - gD \)

Slope = linear relationship with dilutions

HERBIVORY RATE

Decreasing # of Grazers

0 Dilution factor (fraction SW) 1

Phytoplankton growth and grazing at a station in the San Juan Islands

Growth equation: \( \frac{dp}{dt} = \mu p - \chi z p \)
\( \frac{dp}{dt} = \mu p - \chi D p = \mu p - gD p \)
Solution: \( t \ln(p(t)/p_0) = \mu - gD \)

Strom et al. 2001

Small phytoplankton grazed at higher rates than large phytoplankton

Strom et al. 2001

Could grazing contribute to diatom dominance in Puget Sound?