Herbert Inlet Clayoquot Sound Phytoplankton and Water Properties 2014-2024 Comparison

Vernon Reed and Sawyer Townsend
Mentored by Cheryl Greengrove
TESC499

Introduction

Phytoplankton are microscopic algae which are responsible for almost all primary production in the ocean. They form the base of the marine food web and produce the majority of the oxygen in the atmosphere. There are over 20,000 known species of phytoplankton, about 200 of which can be harmful to humans and marine mammals. One such species, *Alexandrium catenella* (Fig. 2), found in PNW waters, produces a neurotoxin which can accumulate in filter-feeding shellfish and can be lethal to marine mammals and humans if ingested by causing Paralytic Shellfish Poisoning (PSP).

University of Washington Tacoma researchers have been studying the marine ecosystem in Clayoquot Sound (Fig. 1) on the west coast of Vancouver Island, BC, Canada annually in the fall since 2001. In 2014, the Northeast Pacific Ocean, including the Pacific Northwest coast, experienced the first of a series of marine heatwaves (MHW). This study will examine the phytoplankton populations and estuarine conditions in Herbert Inlet, one of five inlets in Clayoquot Sound, in 2024 and compare water properties and phytoplankton abundance and diversity in this inlet with data collected in 2014. Water properties and phytoplankton will also be compared with nearby Bedwell Inlet for 2024.

Methods

Study Area & Sampling Design: Sampling was conducted in multiple inlets throughout Clayoquot Sound, BC. (Fig. 1) September 5-7, 2024, as part of an ongoing, 20-year water-property and phytoplankton monitoring project. Fifty CTD stations were sampled, with phytoplankton collected at 19 stations.

Field Sampling: Six water properties (temperature, salinity, density, oxygen, fluorescence, and transmissivity) recorded in continuous profiles with a Seabird 19 CTD at each station. Discrete water samples were taken at the surface and 10-m depths (thermocline) at each station with a Niskin bottle. Concentrated phytoplankton samples taken were with 0-10-meter vertical net tow. All samples were preserved with formalin.

Laboratory & Species Analysis: Phytoplankton identification and enumeration of water samples from bottles and nets were done using a 0.1 mL Palmer-Maloney slide with compound microscope at 400X magnification. Monitoring primarily for *A. catenella*, a toxic dinoflagellate linked to PSP, but recorded all species found. All species counts were compared across sites to identify spatial distribution patterns in abundance and diversity. The Simpson Index was used to calculate phytoplankton diversity.

Data Integration & Use: The MHW year, 2014, was compared with 2024 data and Herbert Inlet was compared with nearby Bedwell Inlet. Environmental water property data were paired with species counts to investigate ecological drivers of harm algae blooms (HABs). Results contribute to datasets informing on shellfish contamination risk and support management and of and public advisory on HABs.

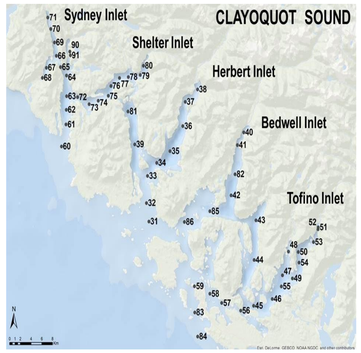


Figure 1: Map of Clayoquot Sound and stations. Photo credit: Tracie Barry.

Figure 2: *Alexandrium catenella.* Photo credit: Sound Water Stewards.

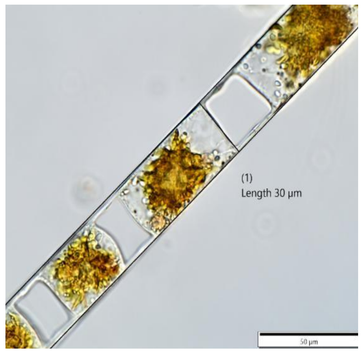


Figure 3: *Hemiaulus hauckii.* Photo credit: Peter Kamen.

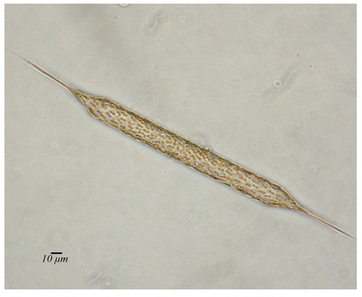


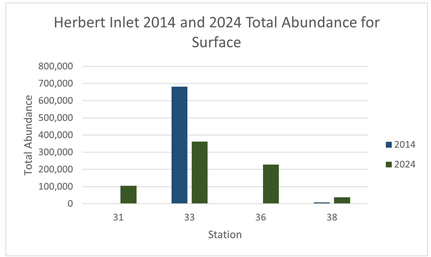
Figure 4: *Rhizosolenia spp.* Photo credit: Mark Webber.

References and Acknowledgements

Results

	Station	Depth	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Herbert	31	srfc	0		0		6,400	0	0	7,874	0	0			0	4,167			0	4,000	20,000
	31	thrm													0	2,654			0	1,709	0
	31	net		180,357	4,651	32,773	28,906	0	0	0	0	8,889			0	210,000			0	60,000	0
	33	srfc	0		1,538	0	752	0	0	6,154	0	0			0	0			0	1,575	3,200
	33	thrm													0	4,202			758	0	0
	33	net		0	11,364	18,803	54,331	0	0	89,286	0	0			0	40,000			0	240,000	0
	36	srfc		0																0	2,542
	36	thrm													0				0	0	0
	36	net																	0	0	0
	38	srfc	0		0	0	8,943	0	0	5,000	0	0			0	2,703			0	0	0
	38	thrm													0	0			855	719	0
	38	net	0	0	1,136	1,786	1,600	0	0	35,088					0	250,000			0	0	0

Figure 5: *A. catenella* concentrations (cells/L) in Herbert Inlet by depth from 2014 to 2024.



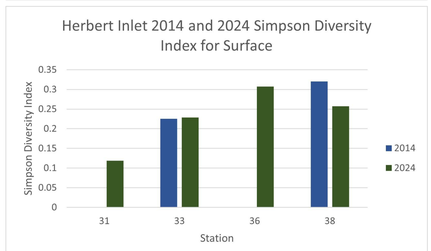


Figure 6a: Total abundance for 2014 and 2024. **6b:** Simpson index values for surface 2014 and 2024.

Year	Station	Depth	Dominant Species
2014	31	surface	*H. hauckii*
2014	33	surface	*H. hauckii*
2015	31	surface	*Phaeocystis spp.*
2015	33	surface	*Phaeocystis spp.*
2015	38	surface	*Phaeocystis spp.*
2018	31	surface	*P. gracile*
2018	31	thermo	*P. gracile*
2018	33	surface	*P. gracile*
2018	33	thermo	*L. minimus*
2018	38	surface	*P. gracile*
2018	38	thermo	*C. closterium*
2019	31	surface	*Rhizosolenia spp.*
2019	31	thermo	*Rhizosolenia spp.*
2019	33	surface	*A. senarius, S. costatum*
2019	33	thermo	*A. senarius, R. setigera*
2019	38	surface	*Chaetoceros spp.*
2019	38	thermo	*A. senarius, Chaetoceros spp, Protoperidinium spp.*
2022	31	surface	*D. brightwelli*
2022	31	thermo	*D. brightwelli*
2022	33	surface	*S. costatum*
2022	33	thermo	*S. costatum*
2022	36	surface	*R. setigera*
2022	36	thermo	*D. brightwelli*
2022	38	surface	*R. setigera*
2022	38	thermo	*Unknown dinoflagellate*
2023	31	surface	*T. nitzschioides*
2023	31	thermo	*C. closterium*
2023	33	surface	*Pseudonitzschia spp.*
2023	33	thermo	*Pseudonitzschia spp.*
2023	36	surface	*D. blavyanus, Chaetoceros spp.*
2023	36	thermo	*C. closterium, T. nitzschioides*
2023	38	surface	*A. senarius*
2023	38	thermo	*D. blavyanus, A. senarius*
2024	31	surface	*S. costatum*
2024	31	thermo	*Chaetoceros spp / T. nitzschioides*
2024	33	surface	*P. delicatissima / R. setigera*
2024	33	thermo	*R. setigera*
2024	36	surface	*L. minimus / R. setigera*
2024	36	thermo	*R. setigera*
2024	38	surface	*L. minimus*
2024	38	thermo	*R. setigera*

Figure 7: Dominant species per station from 2014 to 2024 in Herbert Inlet. Only includes where data was collected and excludes net data.

- Phytoplankton abundance was greatest at station 33 near the mouth of the inlet in 2014 and 2024.
- The highest phytoplankton diversity was found near the head of the inlet in both years (Fig. 6).
- *R. setigera* was the dominant species; 10 times between 2019 and 2024. *A. senarius*, *S. costatum*, and *P. gracile* were each recorded as dominant half as many times as *R. setigera* since 2014. Across all stations over ten years, both surface and thermocline depths, a total of 32 unique species were listed as dominant (Fig. 7).
- No *A. catenella* were found in 2014; in 2024, the concentration was moderate. From 2006 to 2024, *A. catenella* was regularly found at stations 31 and 33. The highest concentration of *A. catenella* was in 2019, which was a high-abundance year for many species (Fig. 5).
- In 2024, Herbert Inlet was warmer, saltier, denser, slightly less anoxic, had greater fluorescence, and lower transmissivity relative to 2014. There is an oxygen minimum at approximately 30-meter depth at the head of the inlet in 2024 (Fig. 8).

Conclusions and Future Work

- The 2014 MHW does not appear to have significantly affected phytoplankton abundance or diversity.
- *A. catenella* is frequently found in the fall annually in Herbert Inlet, especially near the mouth of the inlet where geoduck harvests often occur.
- Highest fluorescence is found in the middle of the inlet rather than the mouth or head.
- The shallow oxygen minimum found near the head may affect migrating salmon.
- Relative to Bedwell, Herbert is colder, saltier, denser, more stratified and has less oxygen, indicating less mixing and flushing across the sill.
- Future research is needed to continue monitoring phytoplankton, and especially *A. catenella* populations and to see if the 2024 oxygen minimum is recurring in Herbert Inlet.

2014 Water Properties

2024 Water Properties

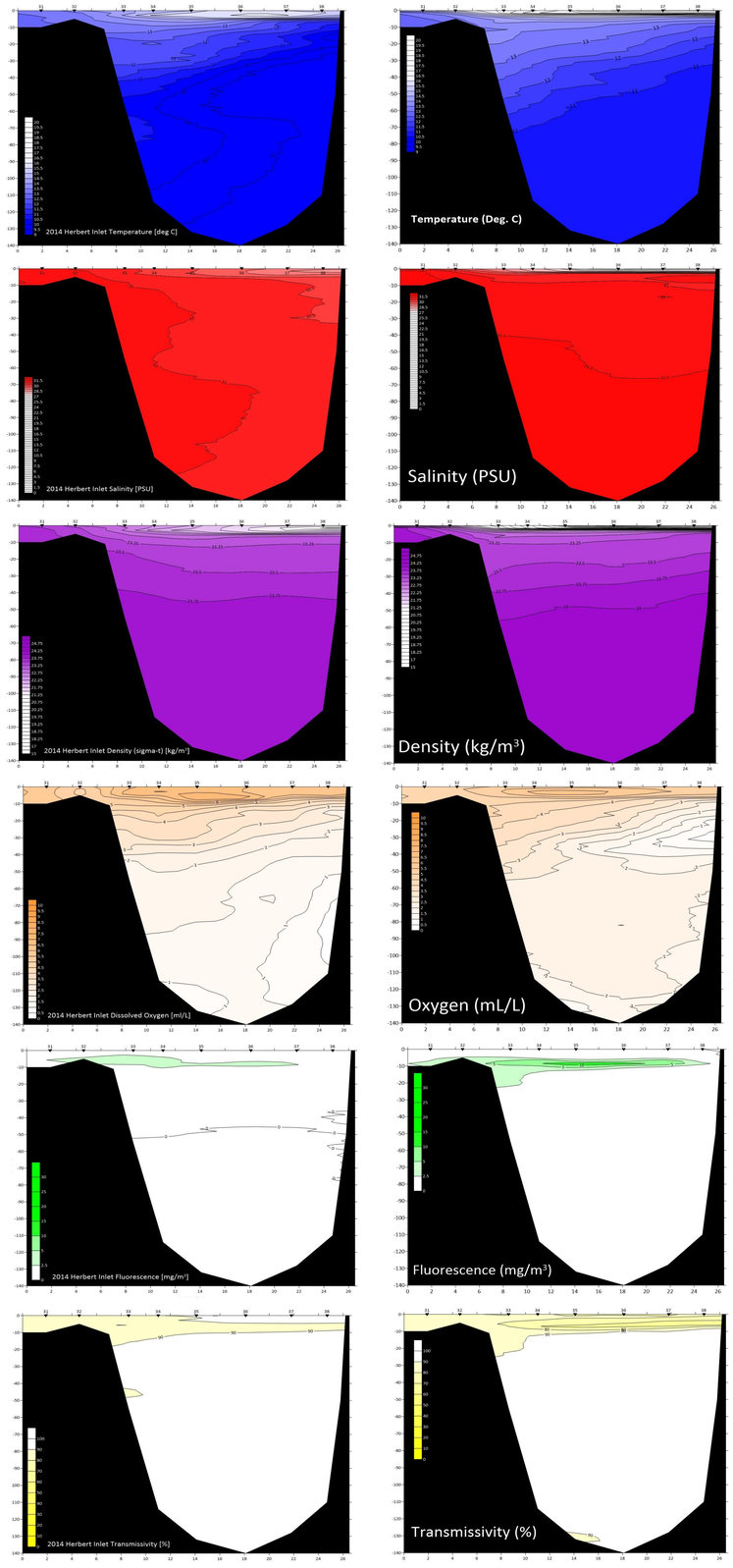


Figure 8a: CTD longitudinal transects of Herbert Inlet water properties in 2014. **8b:** CTD longitudinal transects of Herbert Inlet water properties in 2024.