5-2021

Vignette 02: Lower Trophic Levels in the Salish Sea

Ian Perry
Pacific Biological Station, Department of Fisheries and Oceans

Recommended Citation

Perry, I. (2021). Lower Trophic Levels in the Salish Sea. In K.L. Sobocinski, State of the Salish Sea. Salish Sea Institute, Western Washington University. http://doi.org/10.25710/vfhb-3a69

02

LOWER TROPHIC LEVELS IN THE SALISH SEA: RECENT FINDINGS FROM THE STRAIT OF GEORGIA

Dr. Ian Perry, Pacific Biological Station, Department of Fisheries and Oceans

Plankton form the base of the pelagic marine food web in the Salish Sea, and are eaten by fishes, marine mammals, and seabirds. Plankton include microscopic plants (phytoplankton) and very small animals (zooplankton). They drift in the water but can accumulate in very large numbers as a result of water currents, and growth and reproduction. In the Canadian waters of the Salish Sea (including the Central and Northern Strait of Georgia, and the Strait of Juan de Fuca), diatoms (which are single-celled algae that have a cell wall of silica) make up most (over 90%) of the phytoplankton during spring, but in the summer the phytoplankton are composed of a greater variety of species, in particular of small flagellates (which have cell walls composed of cellulose). Autumn has the greater diversity of phytoplankton species, with a mixture of flagellates remaining from the summer and diatoms beginning to grow again when storms mix nutrients back into the surface layers of the Strait (Nemcek et al. 2020).

Chlorophyll a is the main pigment in plants (it makes them green) and is used as a measure of the amount (or biomass) of phytoplankton. Seasonally, chlorophyll a in the Strait of Georgia is lowest during the winter when there are lots of nutrients but plant growth is limited by low light levels, highest during the spring when nutrients and light are optimal for growth, low during summer when nutrients are low, and higher again with episodic blooms during the autumn caused by wind events, which replenish the nutrients in the upper water layers (Figure 1, Suchy et al. 2019).

Phytoplankton chlorophyll concentrations have been monitored by satellites since 2003 and have been used to understand year-to-year changes in the amount of phytoplankton in the Strait of Georgia (Suchy et al. 2019). Moderate to high concentrations of chlorophyll a occurred in this region in 2005 and 2015, concurrent with early and strong flows of freshwater from the Fraser River into the Strait of Georgia, and with low numbers of windstorms. Chlorophyll a in the Northern Strait of Georgia over the period 2003 to 2016 was related to the temperature at the surface of the water and to the amount of light available for the plants to grow (which varies among years depending on cloud cover). In the Central Strait of Georgia over this same time period, Chlorophyll a concentrations were related to the amount of freshwater flowing from the Fraser River. All of these physical processes (sea temperature, amount of light for growth, and freshwater from the Fraser River) control the extent of vertical mixing in the Strait of Georgia, which in turn controls the amount and types of phytoplankton that grow in the Strait during the year. The median Chlorophyll a concentration in the Northern Strait of Georgia is also related to several atmosphere/climate indices, such as the Pacific Decadal Oscillation, but not in the Central Strait. This suggests that phytoplankton dynamics in the Central Strait of Georgia are more strongly influenced by local factors, such as flow from the Fraser River. While Chlorophyll a is an indicator of phytoplankton biomass, it does not tell the entire story of phytoplankton production because much of the phytoplankton is consumed by zooplankton.

Zooplankton are the small animals that largely feed on the phytoplankton, and in turn are eaten by other zooplankton, fishes, marine mammals, and seabirds. They have been monitored consistently in the Central and Northern Strait of Georgia since 1996 (Mackas et al. 2013). Total zooplankton biomass was highest in the late 1990s, then declined quickly to a minimum in 2005, and has recovered since 2010 to above normal biomass levels (Figure 2; Perry et al. 2021). Most (76%) of the biomass of zooplankton are composed of four types of animals: medium and large copepods, euphausiids, and amphipods. Interannual changes in zooplankton biomass over this period were related to the salinity at the sea surface, the timing of the bloom of phytoplankton during the spring, and the Pacific Decadal Oscillation (a large-scale climate index).

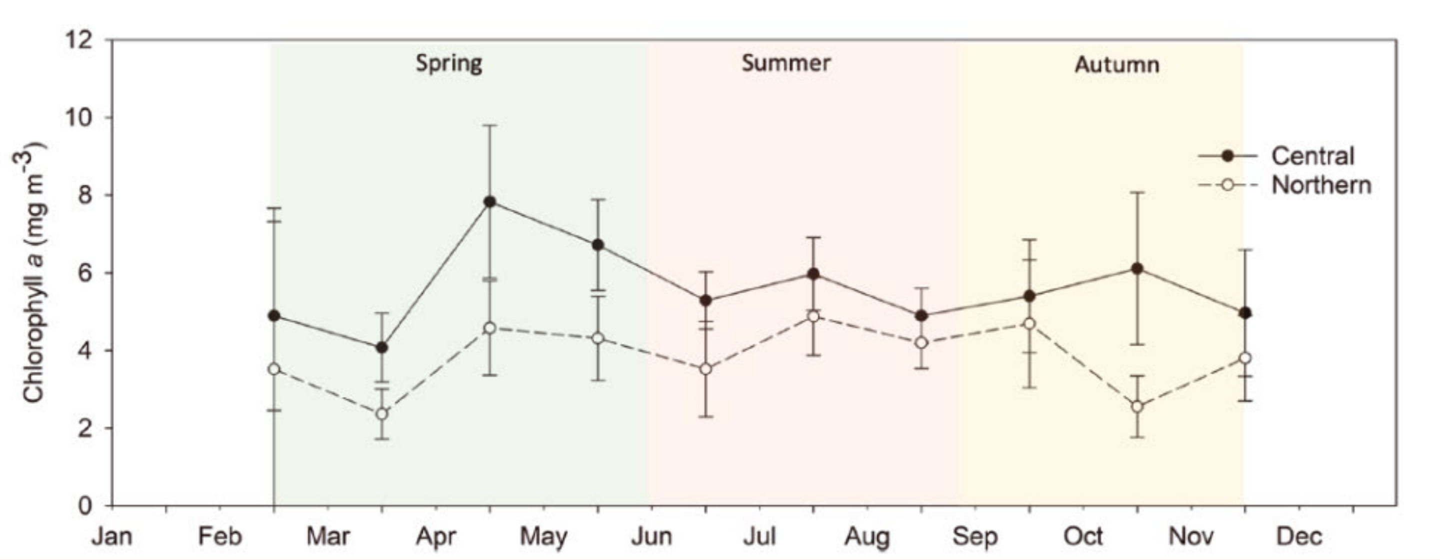

Figure 1. Typical pattern of monthly chlorophyll a concentrations in the Central and Northern regions of the Strait of Georgia as determined from weekly satellite remote sensing from 2003 to 2016. Vertical bars represent the 95% confidence intervals about the monthly mean values. Source: Reproduced from Suchy et al. (2019).

Zooplankton abundance is important for the marine food web, and variations in the types of zooplankton and their abundance can impact growth and survival of fishes. Statistical models that included salinity, sea temperature, freshwater flow from the Fraser River, and the wind over the sea surface (all of which control the vertical mixing of the water column and the circulation in the Strait of Georgia), as well as zooplankton biomass, explained much (38-85%) of the interannual variability of the early marine survival rates of three populations of Chinook salmon in the Canadian waters of the Salish Sea. However, these analyses were based on conditions that occurred from 1996 to 2018; if climate change pushes conditions outside of those observed during this period, these statistical relationships may break down. Climate change—and the resulting change in river flow, temperature, or wind patterns—may lead to unusual and unexpected patterns of phytoplankton and zooplankton, which in turn could affect early marine Chinook salmon survival and the growth and development of other zooplankton-eating organisms.

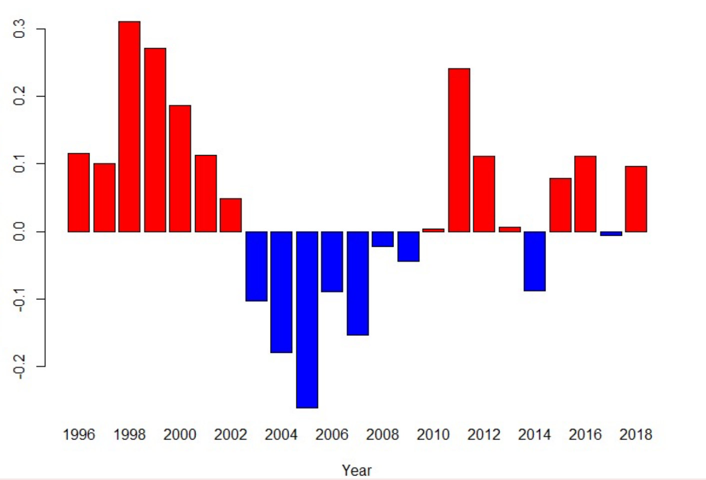

Figure 2. Total zooplankton biomass in Central and Northern Strait of Georgia, 1996 to 2018 (values shown are 'anomalies' or differences from the average values between 1996 to 2010). Source: Modified after Perry et al. (2021).