Chlorophyll Dynamics in the Southern California Bight

Craig Gelpi
Catalina Marine Society
craig@catalinamarinesociety.org

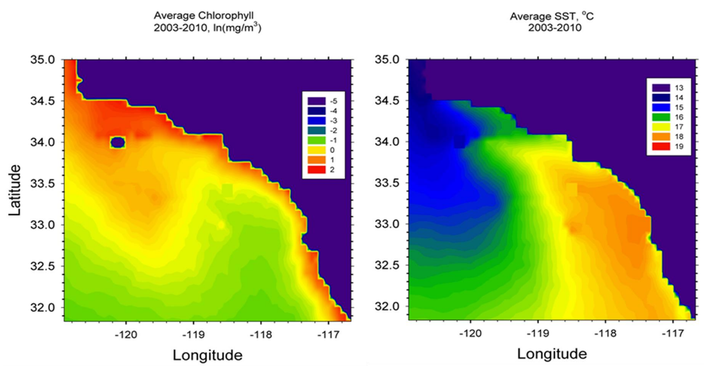
Abstract

We analyze a multi-year time series of MODIS chlorophyll product at high spatial resolution to determine spatial and temporal dynamics of chlorophyll in the Southern California Bight. These dynamics are compared to advection and upwelling patterns as well as to the average vertical eddy diffusion coefficient for the center of the Bight. We find the most chl-a events as well as the maximum values of chl-a to be in the Santa Barbara Channel. This source of chl-a is advected southeast to engulf San Nicolas Island, making the region surrounding this island to be the most chlorophyll rich among the Southern Channel Islands. In contrast, the other major Southern Channel Islands, San Clemente, Santa Barbara and Santa Catalina, do not exhibit any local enhancement in chlorophyll. Chl-a is found to have annual cycles in the region of the Southern Channel Islands that initialize nearly simultaneously in late winter or spring. However, the local blooms at Santa Catalina commence earlier, are shorter lived and do not attained the maximum chl-a values found at San Nicolas.

Introduction

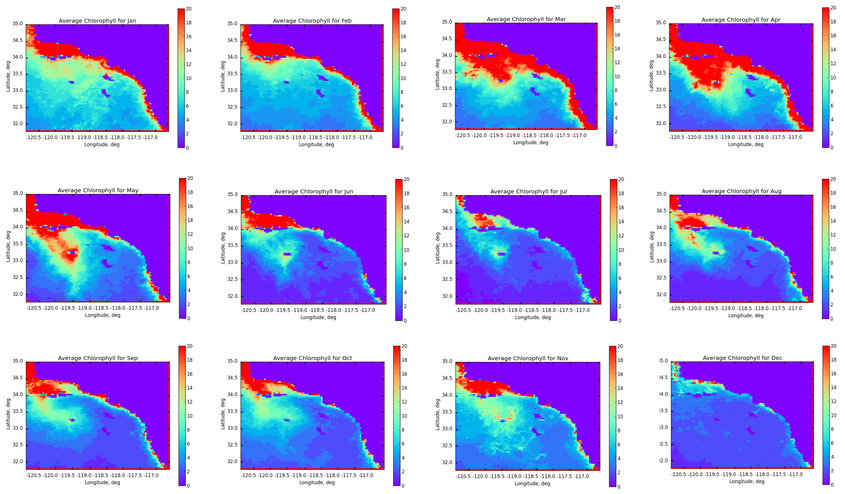
A previous analysis of long-duration (decade) temperature data from the Southern California Bight indicates that a 1-dimensional model of insolation and vertical diffusion well explains the seasonal temperature variation. This result suggests that the inner bight is somewhat isolated and may be used as a field location for studies involving vertical diffusion, such as nutrient replenishment. The present work examines how isolated the inner Bight and Santa Catalina island are with respect to phytoplankton (i.e., chlorophyll) advection.

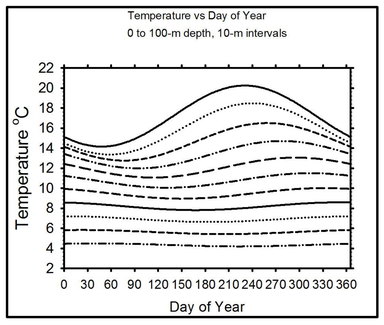
The location is the Southern California Bight, adjacent to the California Current System, an eastern boundary current. Nominally equatorward winds are offshore along northern and central California producing upwelling and phytoplankton blooms.



Long-term averages of Modis Chl-a product and SST indicate the two spatial distributions are grossly complementary with warmer water toward the south and coast and larger Chl-a values toward the north, especially in the Santa Barbara Channel. Note that the SST maximum is at 33° N, and indicates the relative isolation of this portion of the Bight.

Ten years of 8-day, 4-km Chl-a product were used to construct monthly averages of the spatial distribution of Chl. The Santa Barbara Channel is seen to contain the largest values of chlorophyll. This high-Chl region expands southeast to engulf San Nicolas Island in March, and retracts in May, though leaving a region of enhanced Chl around San Nicolas. This enhanced Chl remains until December.





Temperature Model for Southern California Bight

$$T = T_2(z,t) + T_1(z) + T_0$$

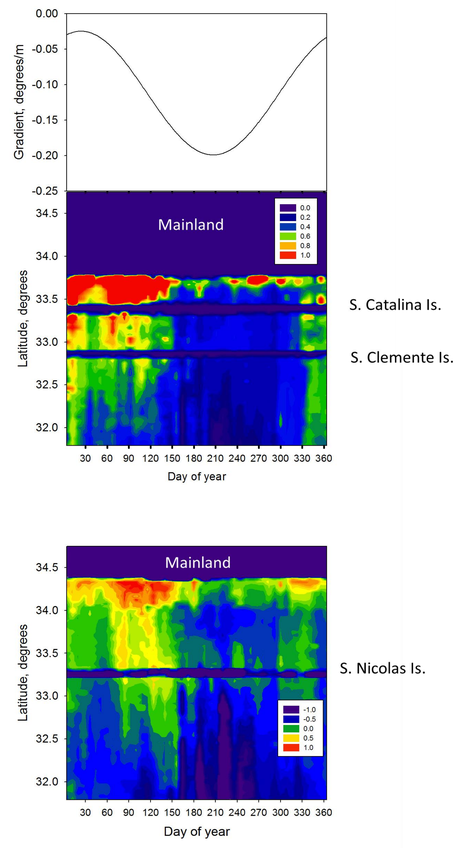
$$T_1 = -\frac{L_0}{c_p \rho \kappa} z$$

$$T_2 = \frac{L_1 \beta}{2ic_p \rho \kappa \alpha}\left(\frac{e^{-\beta z} - e^{i\alpha z}}{i\alpha + \beta} + \frac{1}{i\alpha - \beta}\right)e^{-i\omega t}$$

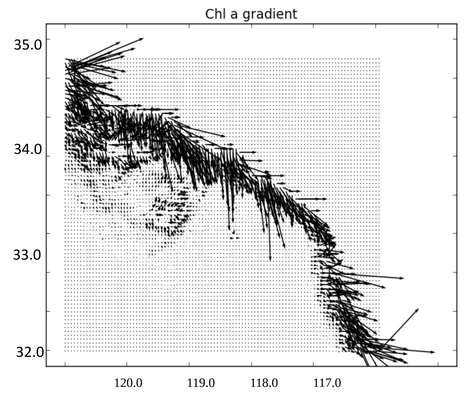
T temperature
T_0 average surface temperature
T_1 time-independent, depth dependent
T_2 seasonal amplitude

z depth
ρ water density
β optical absirption depth
κ diffusion coefficient
c_p specific heat capacity of water
L_0 average energy flux
L_1 amplitude of seasonal energy flux

The Chl-a temporal behavior on a latitudinal profile (-118.42°) through Santa Catalina and San Clemente, compared to the model temperature gradient. Chl is reduced when the gradient exceeds -0.1 degrees/m. A latitudinal profile through San Nicolas suggests that Chl originates there.



The average Chl for each of the 460 files (time periods) is used to normalize the values for the time period, then the spatial gradient is computed and averaged among the periods. The gradients are strongest along the coast; they also indicate activity around San Nicolas Island.



Summary

Temporal and spatial analysis of MODIS Chl-a product indicates that the inner Southern California Bight, including the islands Santa Catalina and San Clemente, behaves as typical temperate ocean with greater productivity during colder well-mixed times and poorer productivity when stratification is large. This area is a good candidate to analyze vertical nutrient diffusion.

However, Chl-a activity is found all year at San Nicolas Island. During the winter and spring, the island is engulfed with chlorophyll, apparently advected from the Santa Barbara Channel. During the summer and fall, the configuration of chlorophyll suggests that there is an island mass effect associated with San Nicolas.