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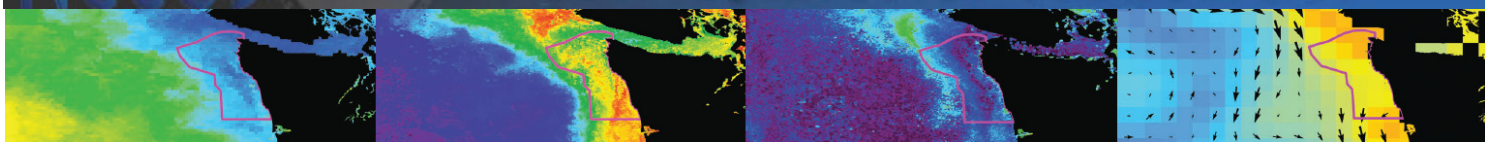
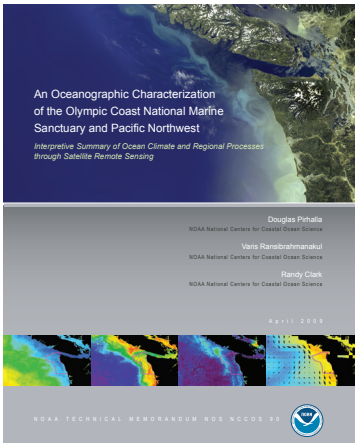


An Integrated Summary of Ocean Climate Data for Sanctuaries

Plotting the Course for Applied Observational Satellite Data



Marine plants and animals rely on specific oceanographic conditions, cues, features and processes, for their survival and reproduction. Understanding how ocean metrics such as water temperature, currents, chlorophyll production, turbidity, winds and fronts change over time and space in the region of a Marine Protected Area (MPA) is an important first step in resource evaluation and assessment. Using satellite observational data series (climatologies) of six ocean variables, scientists from NOAA's Center for Coastal Monitoring and Assessment (CCMA) evaluated and summarized surface patterns, features and underlying processes governing oceanographic variability and climate for the Pacific Northwest, in particular, the Olympic Coast. Goals were to provide a climatological baseline for evaluating future oceanographic trends and anomalies in the data, and to document a process for integrating merged satellite remote sensing information into NOAA-supported ecosystem MPA assessments and evaluations.

Report Highlights

• The Olympic Coast National Marine Sanctuary (OCNMS) exhibits distinct seasonal patterns in six ocean variables including sea surface temperature (SST), sea surface height anomalies (SSHA), ocean color chlorophyll and turbidity, and strong seasonal forcing mechanisms (currents and winds) on surface response characteristics (Figure 1).

• Five distinct seasonal cycles were evident for the OCNMS (Figure 2) including:

-Winter Downwelling (Nov- mid Feb)
-Spring Transition (late Feb- Mar)
-Spring/early summer bloom period (Apr- Jun)
-Late summer/early fall transport and upwelling period (Jul- Oct)
- Fall Transition (mid Oct- Nov)

• Highlighted were the linkages between seasonal effects of warming/cooling and process-related effects such as wind- driven upwelling/ downwelling, and physical transport.

• Also highlighted were how ocean conditions change from year to year (interannual cycles), including how they are influenced by El Niño Southern Oscillation (ENSO).

• For many protected areas, basic biological and physical data are lacking in spatial and/or temporal resolution. Satellite remote sensing requirements to fill existing gaps in baseline information for sanctuaries were identified and documented.

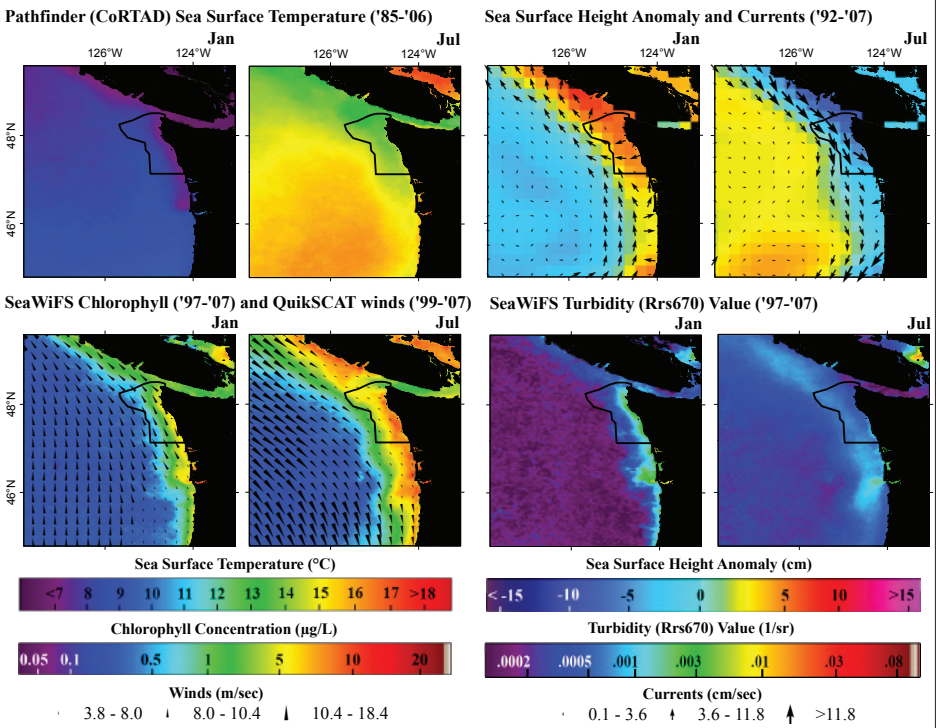


Figure 1. Climatological summaries of monthly averaged satellite oceanographic data during peak of winter downwelling period (January), and upwelling period (July). Note distinct variable response pattern changes for the two periods. See report for complete details on data, methods, technical disclaimers, and references.

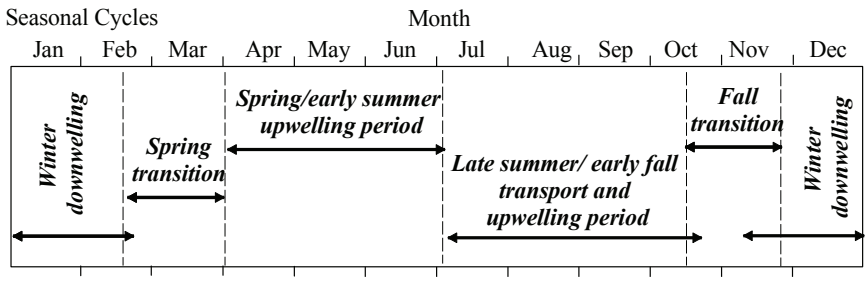


Figure 2. Diagram of seasonal breakouts and periods of transition for the Olympic Coast Sanctuary. Divisions were characterized by surface chlorophyll patterns and circulation drivers for the Olympic Coast region.

Regional (OCNMS) Highlights

• SST fronts and chlorophyll variability estimates reveal both ephemeral (short-lived) and persistent surface features (Figure 3) for the OCNMS, indicative of the Juan de Fuca eddy circulation, upwelling fronts located inside and outside sanctuary boundaries, and offshore wind- and Columbia River plume-induced fronts (not shown).

• Correlation patterns among precipitation, discharge, and ocean color in **January** suggest a strong coastal precipitation-effect on surface sediment response characteristics inside the sanctuary (Figure 4, 5).

• Correlation patterns among SST, SSHA, and ocean color in **May** suggest that increased regional heating, physical circulation and mixing processes limit chlorophyll production most dramatically (Figure 5).

• Correlation patterns among SST, SSHA, and ocean color in **July** suggest that increased light and temperature, along with upwelling, drive chlorophyll production inside the sanctuary (Figure 5).

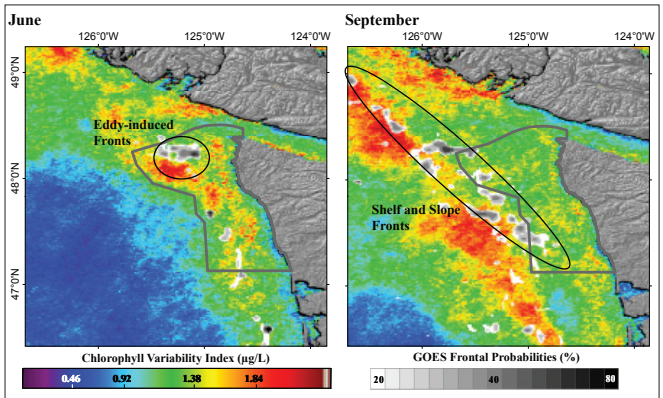


Figure 3. Climatological GOES SST fronts and SeaWiFS chlorophyll variability estimates for June and September. Note the occurrence of persistence fronts and increased variability outside the OCNMS.

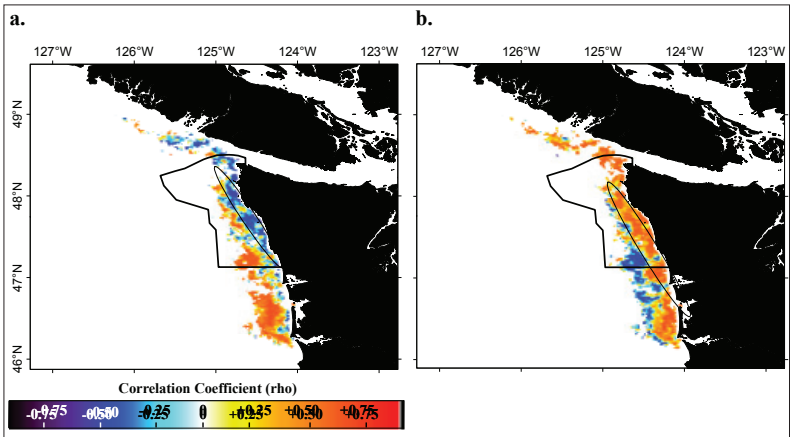


Figure 4. Spearman correlation coefficients (rho) show strength and direction (+/-) of spatio-temporal relationship between SeaWiFS January turbidity and (a) USGS gauged Columbia River January discharge and (b) GPCC January precipitation.

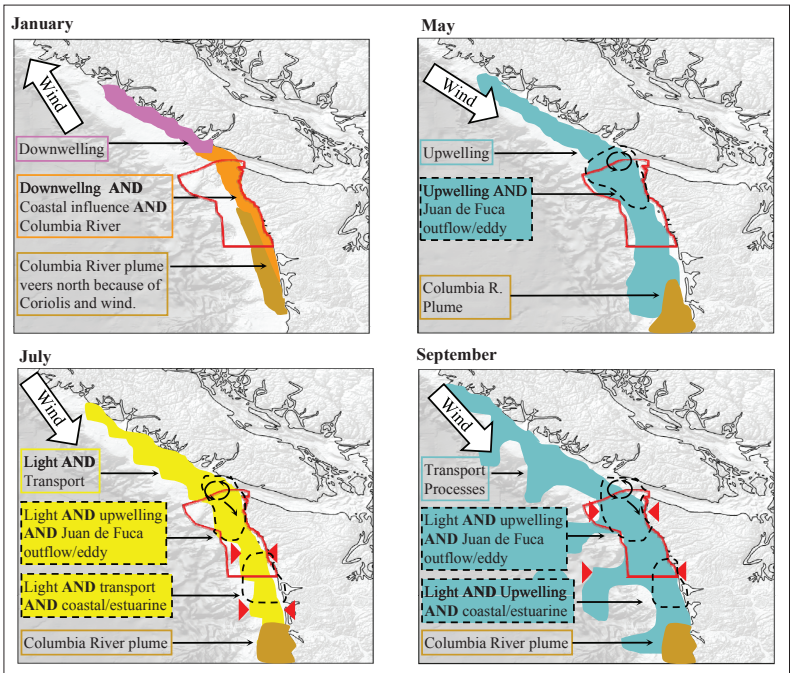


Figure 5. Schematic of general physical factors limiting nutrient availability and surface response during January, May, July, and September. Boundary determinations based on correlation patterns of spatially and temporally resolved remote sensing parameters, Columbia River discharge and watershed-based precipitation estimates.

• Correlation patterns in **September** suggest that coastal processes (Juan de Fuca outflow and Ekman transport) lead to fall chlorophyll maximums inside the sanctuary (Figure 5).

The Data

Satellite data archives were acquired from NOAA, NASA, and other world-wide operational data centers. This report merges eight climatological datasets, utilizing six data sources, spanning up to 22 years of temporal coverage. The collection of spatial, temporal, derived, and primary remote sensing (and other) datasets is available from CCMA upon request.

Future Applications

This work was intended to demonstrate a core use of satellite ocean climate data for site characterizations and evaluations of MPAs. Future work will be to integrate climatological baseline information from satellite with coastal ocean modeling outputs, spatial habitat data, and key biological/ecological information to provide managers with an important new tool for spatial gap analyses, ocean use, and other natural heritage elements for MPAs.

This report and associated products also represent the first of many steps to address present and future management questions by the OCNMS in their plan review process. These and supporting methods are poised to be the foundation for continuing ecological assessments conducted in partnership with NOAA, OCNMS, other Federal and State agencies, tribes, and the research community vested in ocean science.

To Learn More

For more information or hardcopy version of the report, please contact the NCCOS Coastal and Oceanographic Assessment, Status & Trends (COAST) at 301-713-3028, or contact doug.pirhalla@noaa.gov. To download a copy of the report, visit http://ccma.nos.noaa.gov/ecosystems/sanctuaries/olympic_nms.html.