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Descriptive time series of environmental factors for four oyster growing areas in BC from 2002 to April 2017

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Summary: time series of environmental parameters in oyster-harvesting zones

Literature indicates that environmental parameters may be predictive of norovirus outbreaks associated with contaminated shellfish.¹⁻⁴ We gathered several years' worth of environmental data (2002-April 2017) for four oyster harvesting zones (Figure 1) that have previously been associated with norovirus outbreaks.⁵⁻⁷ Environmental data was gathered for:

1. rainfall,
2. salinity,
3. sea surface temperature,
4. upwelling (an indication of the strength of the wind's force on the ocean), and
5. sunlight (a.k.a. photosynthetically active radiation)

Environmental parameters that may be predictive of outbreaks but which were *not* included in this report include: freshwater discharge, a measure of water entering the ocean from rivers or streams; wind speed and direction; gage height, a measure of the depth of water around shellfish farms; and pH. A hydrology expert advised that freshwater discharge for regions in coastal BC should be considered from two types of rivers, those draining the interior (dominated by summertime snowmelt) and those draining the coast (dominated by rainfall in winter). Data for all zones from both types of river were not available for the entire time period of interest. Wind was not included as wind speed and direction were not meaningfully aggregated at the zone-level, and wind varies too much at the small geographic scale. Gage height was not included as there is no reliable measure of this for BC shellfish harvesting areas.

It was hoped that these data would feed into the development of a random forest model that would identify which parameters are most predictive of oyster-associated norovirus outbreaks. The outcome of interest in this case is either the presence of norovirus in oysters or the existence of oyster-associated norovirus outbreaks in humans. There is no ongoing monitoring of norovirus levels in BC oysters, nor is norovirus illness in humans reportable, so there is limited outcome data available. Unfortunately, random forest modelling works best with balanced outcome data (where a binary outcome is split 50:50); this was not the case with the outbreak data available for use in modelling norovirus outbreaks in BC. Instead, we opted to create descriptive time series plots using parameter data, to visualise how environmental conditions varied during outbreak years and years with no recorded outbreaks.

These time series plots suggest that known outbreaks have occurred during periods of heavy rainfall, low sea surface temperature, low sunlight, and during periods of downwelling, i.e. when the wind forces water in a downwards movement from the sea surface during fall and winter seasons.

However, there have been periods with similar environmental conditions when norovirus outbreaks linked to raw oyster consumption were not noted. These environmental data are now available, but need to be examined more rigorously to establish these environmental factors as predictive for norovirus illnesses linked to raw oyster consumers.

If you have any questions about this time-series please contact fpinfo@bccdc.ca

Methods

Monthly aggregates of daily parameters were plotted for four oyster harvesting zones (see table 1 for description of harvesting subareas included in zones, and figure 1 for a map of these areas), with periods of known oyster-associated norovirus outbreaks highlighted for comparison. For details on sources of data and specific stations used for measurements, see table 2.

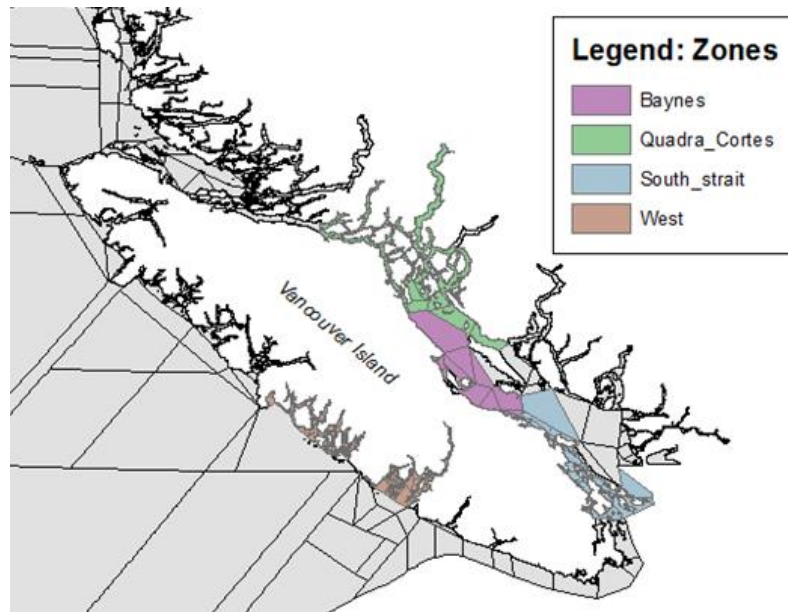


Figure 1. Map of time-series zones.

Table 1. Oyster harvesting zones for time series environmental analyses

Zone name	Baynes	Quadra Cortez		South strait		West	
Harvest areas	14	13	15	17	18	23	24
Subareas	All	All	2-5	All	All	All	All

List of time series figures

1. Mean daily rainfall by month
2. Max daily rainfall by month
3. Daily salinity by month
4. Mean daily upwelling by month
5. Max daily upwelling by month
6. Mean daily solar radiation by month
7. Max daily solar radiation by month
8. Mean daily sea surface temperature by month
9. Max daily sea surface temperature by month

Table 2. Parameter definitions and data sources for time series environmental analyses

Parameter	Definition	Data source	Stations, notes
<p>Rainfall</p> <ul style="list-style-type: none"> • Mean daily (mm) • Maximum daily (mm) 	<ul style="list-style-type: none"> • Mean measurement across all stations in zone, daily • Max measurement across all stations in zone, daily 	Environment Canada Stations (via Pacific Climate Consortium data tool)	<ul style="list-style-type: none"> • Baynes: Mud Bay, Courtenay Graham, Qualicum Fish Research • Quadra_Cortes: Heriot Bay, Cortes Tiber Bay, Cape Mudge. • South_strait: N Pender, Galiano N, Entrance Isl, Nanaimo City Yard • West: Ucluelet Kennedy Camp, Tofino A, Lennard Isl
Salinity, daily (psu = practical salinity units)	Daily sensor measurement of salinity at various stations.	BC lighthouse data, DFO	<ul style="list-style-type: none"> • Baynes, Quadra_Cortes: Chrome Island • South_strait: Entrance Isl. • West: Amphitrite Point
Upwelling (m ³ /s/100m coastline)	<p>Strength of the wind forcing on the ocean, taken every 6h at two sites along the BC coast. Mean and max daily measurements recorded.</p> <p>(Positive values indicate upwelling conditions, while large negative values indicate downwelling.)</p>	National Oceanic and Atmospheric Administration (NOAA) Environmental Research Division	All harvest areas were closest to the station at these coordinates: 48,-125
<p>PAR- photosynthetically active radiation</p> <p>(unit of energy = W/m²)</p>	<p>The amount of light available for photosynthesis, which is light in the 400 to 700 nanometer wavelength range.</p> <p>Measured daily.</p>	MODIS, National Oceanic and Atmospheric Administration (NOAA) Environmental Research Division.	Data were extracted for each harvest area, then averaged across zones.
SST- sea surface temperature	Temperature at the surface of the ocean, measured by remote sensor. Measured daily.	MODIS, National Oceanic and Atmospheric Administration (NOAA) Environmental Research Division.	Data were extracted for each harvest area, then averaged across zones.

Results

1. Mean daily rainfall by month

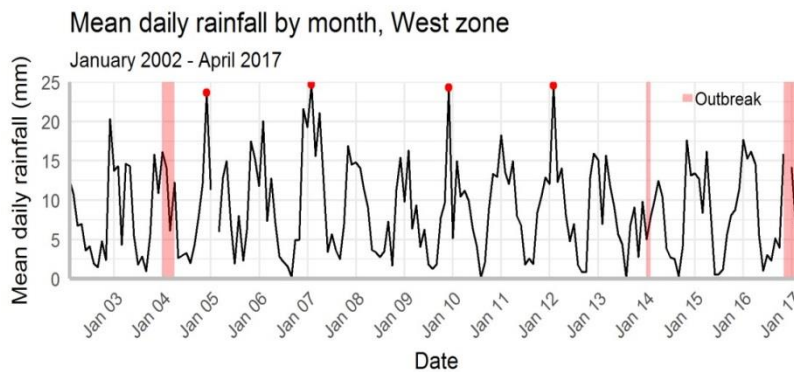
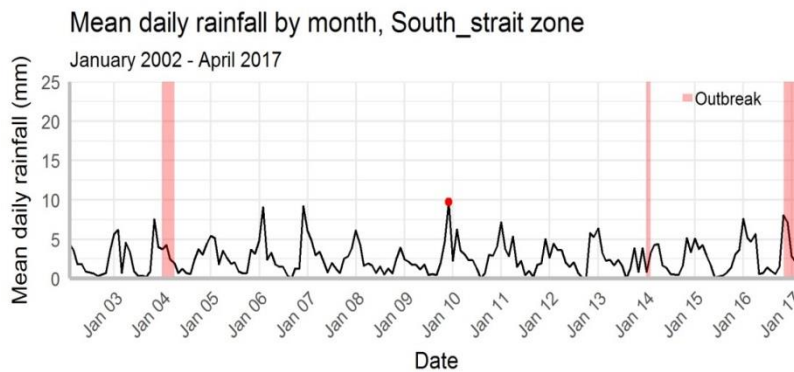
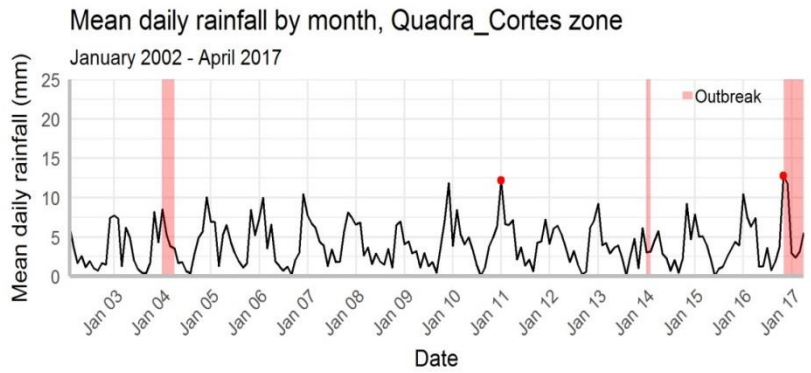
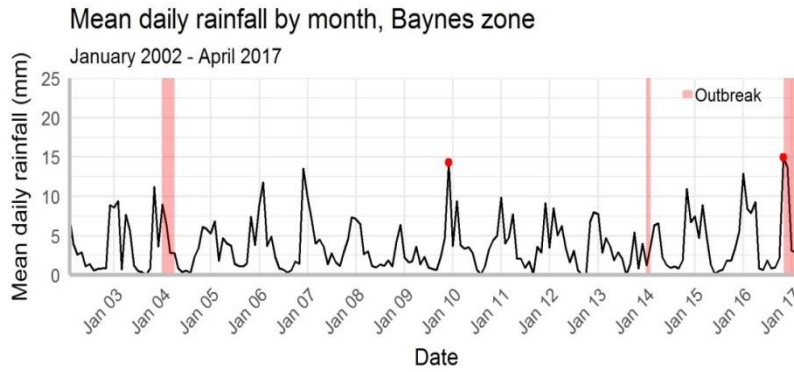
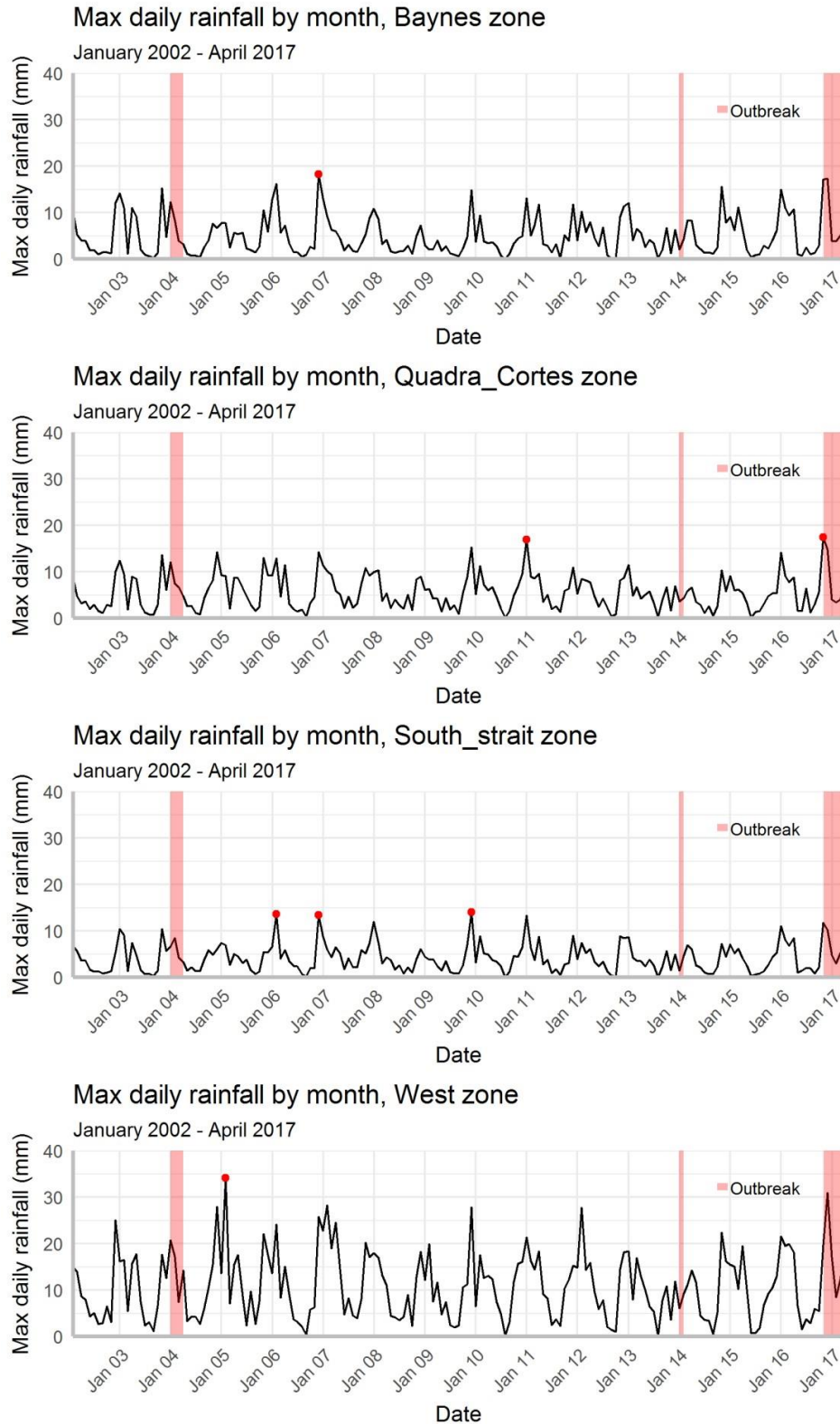


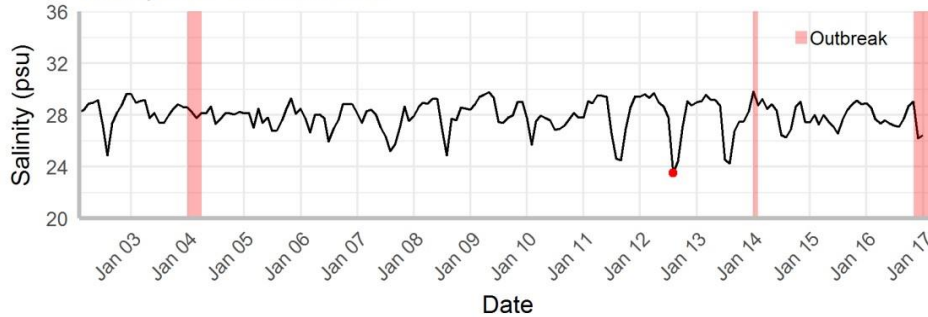
Figure 2. Max daily rainfall by month



3. Mean salinity by month

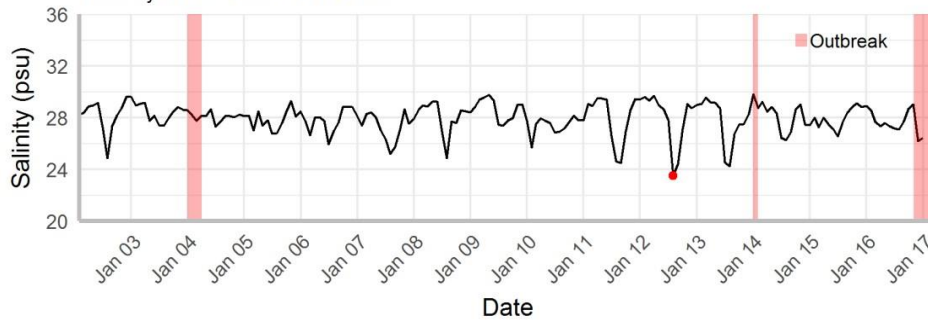
Mean monthly salinity, Baynes zone

January 2002 - December 2016



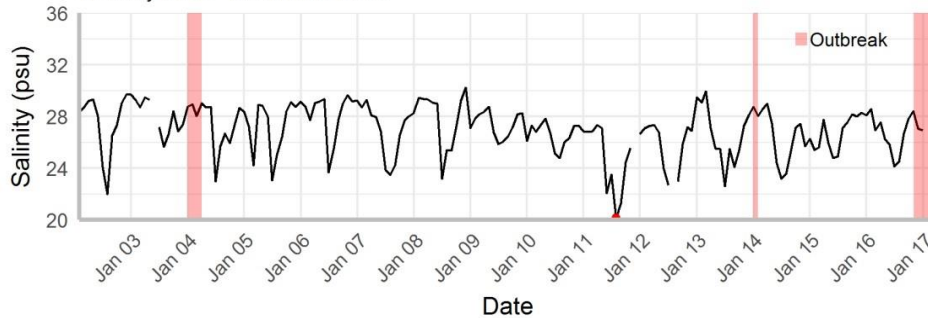
Mean monthly salinity, Quadra_Cortes zone

January 2002 - December 2016



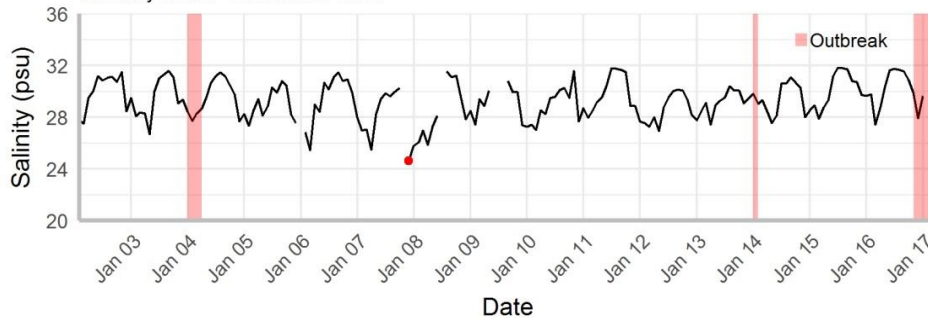
Mean monthly salinity, South_strait zone

January 2002 - December 2016

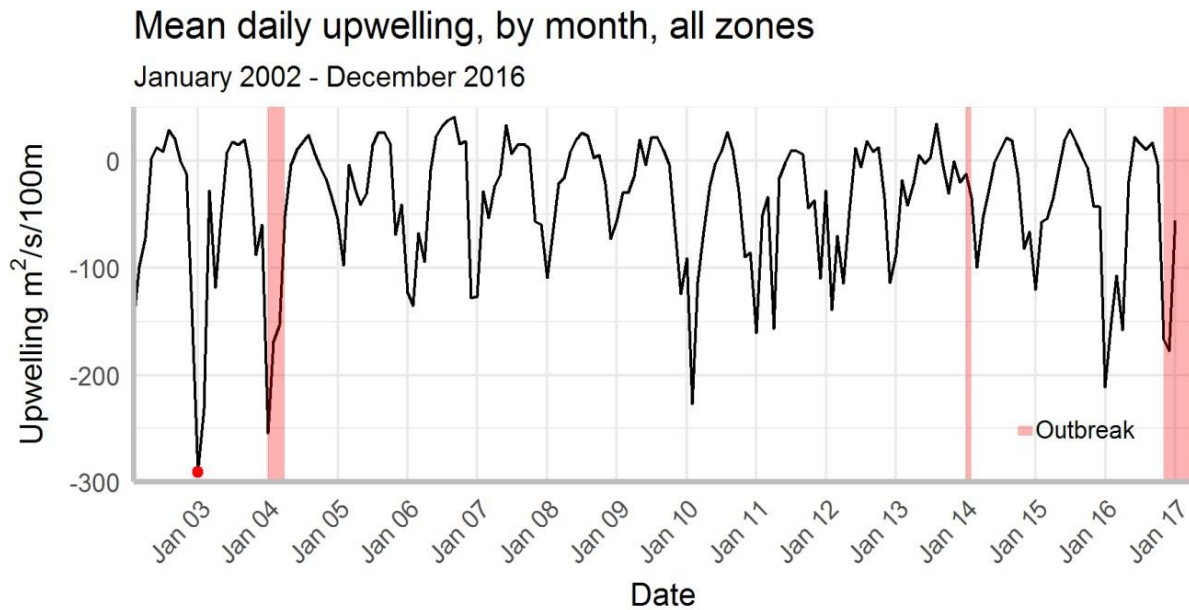


Mean monthly salinity, West zone

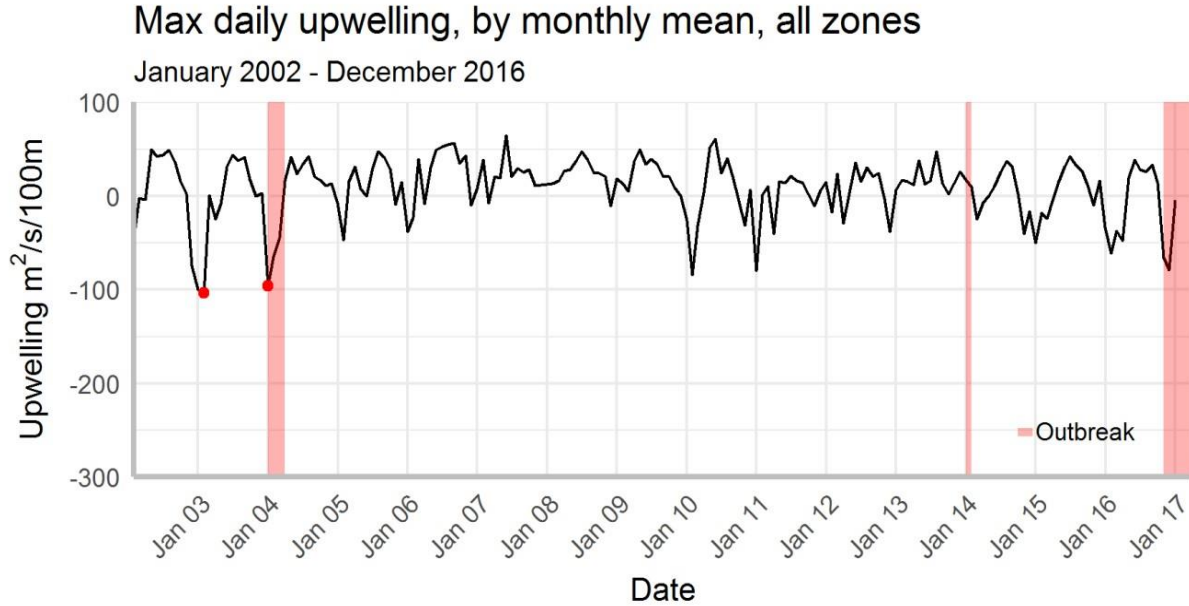
January 2002 - December 2016



4. Mean daily upwelling by month



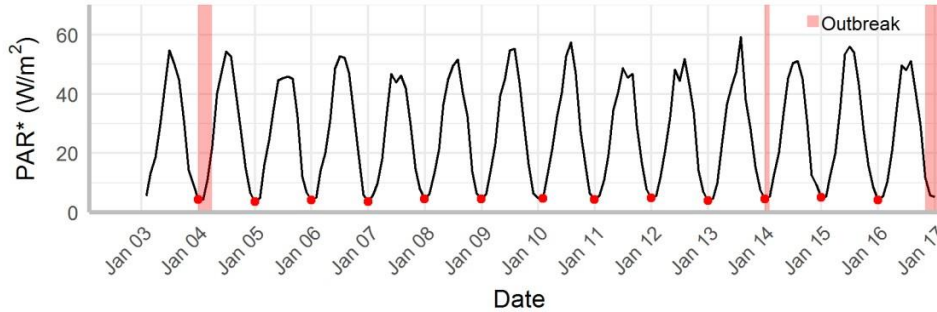
5. Max daily upwelling by month



6. Mean daily solar radiation (PAR) by month

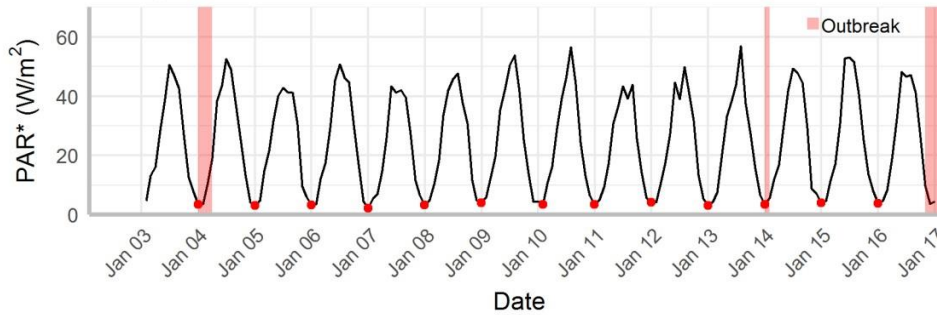
Mean daily solar radiation by month, Baynes zone

January 2003 - December 2016



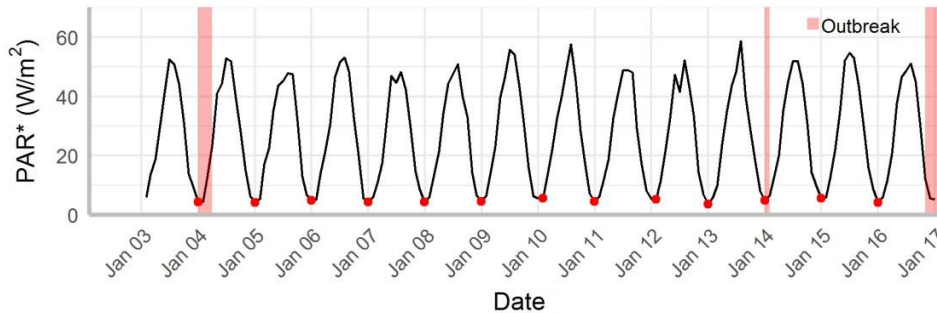
Mean daily solar radiation by month, Quadra_Cortes zone

January 2003 - December 2016



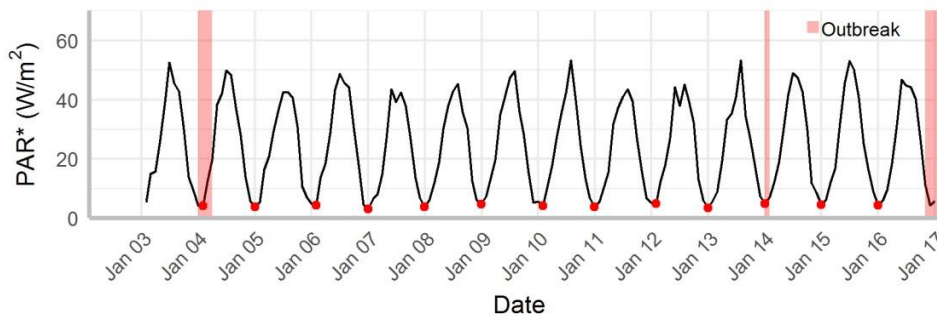
Mean daily solar radiation by month, South_strait zone

January 2003 - December 2016



Mean daily solar radiation by month, West zone

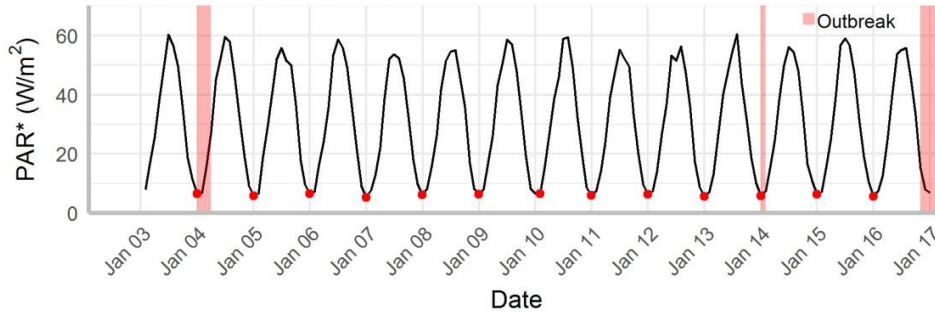
January 2003 - December 2016



7. Max daily solar radiation (PAR) by month

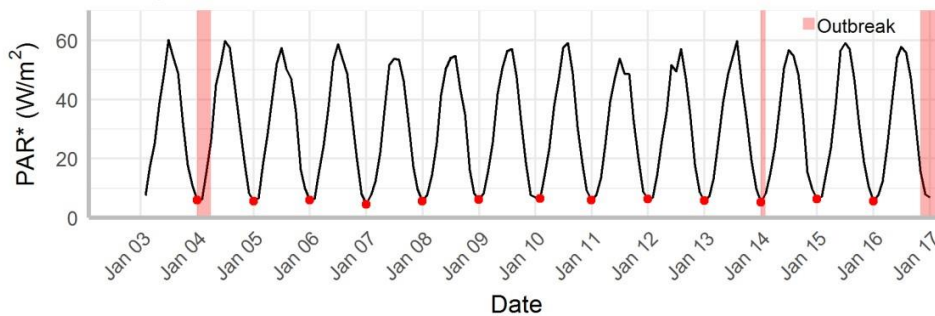
Max daily solar radiation by month, Baynes zone

January 2003 - December 2016



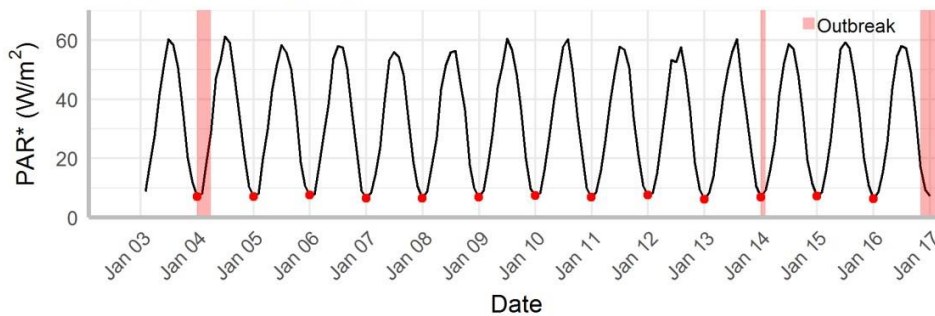
Max daily solar radiation by month, Quadra_Cortes zone

January 2003 - December 2016



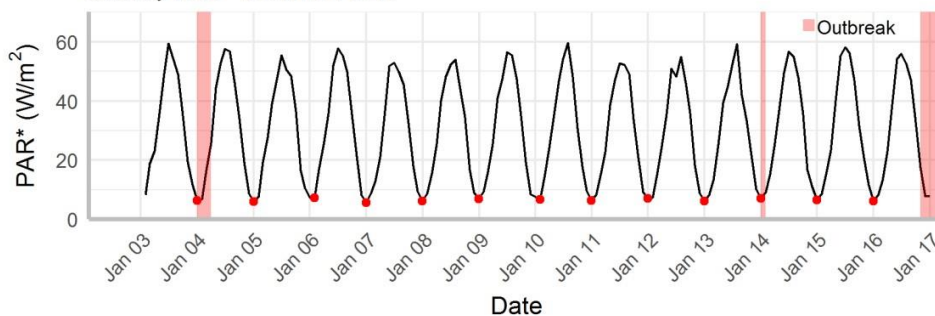
Max daily solar radiation by month, South_strait zone

January 2003 - December 2016



Max daily solar radiation by month, West zone

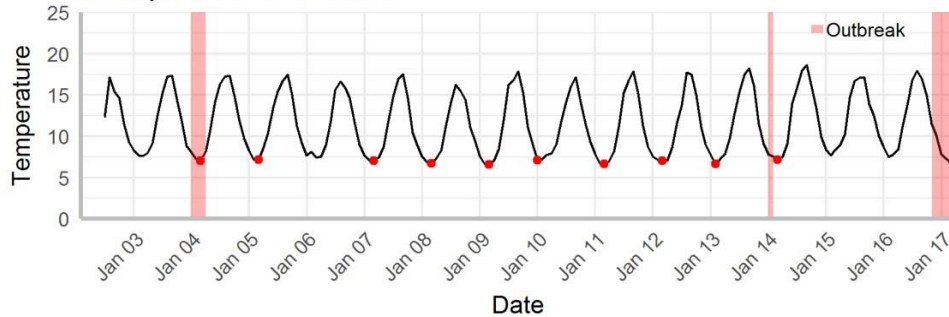
January 2003 - December 2016



8. Mean daily sea surface temperature by month

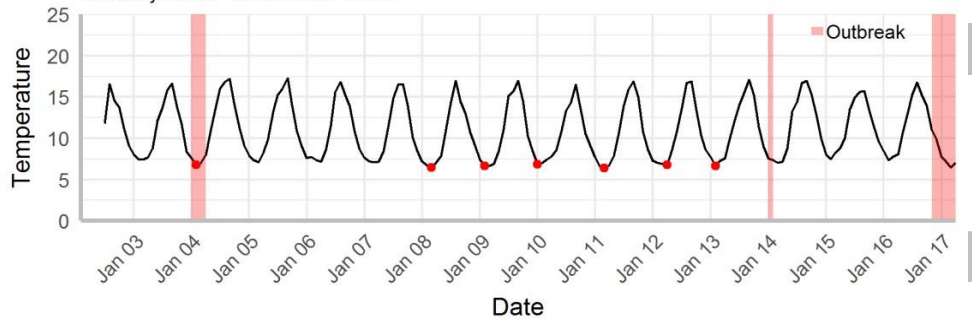
Mean daily sea surface temperature by month, Baynes zone

January 2003 - December 2016



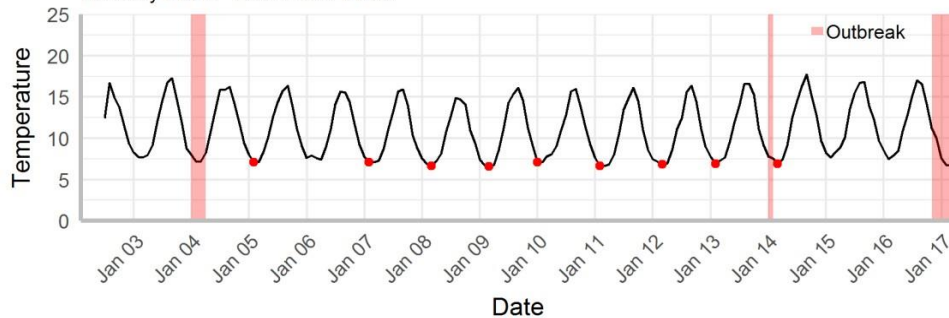
Mean daily sea surface temperature by month, Quadra_Cortes zone

January 2003 - December 2016



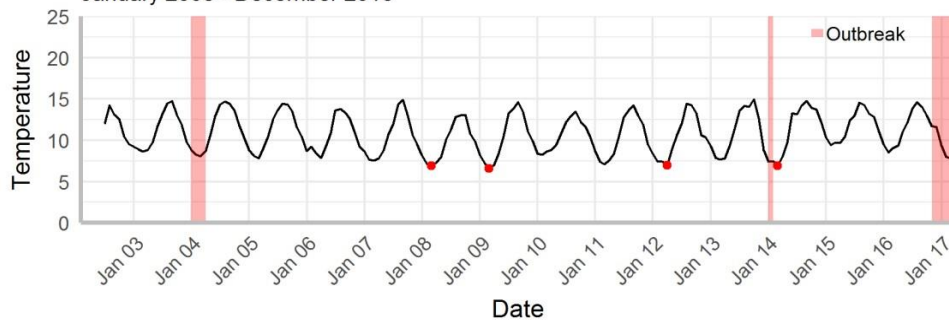
Mean daily sea surface temperature by month, South_strait zone

January 2003 - December 2016



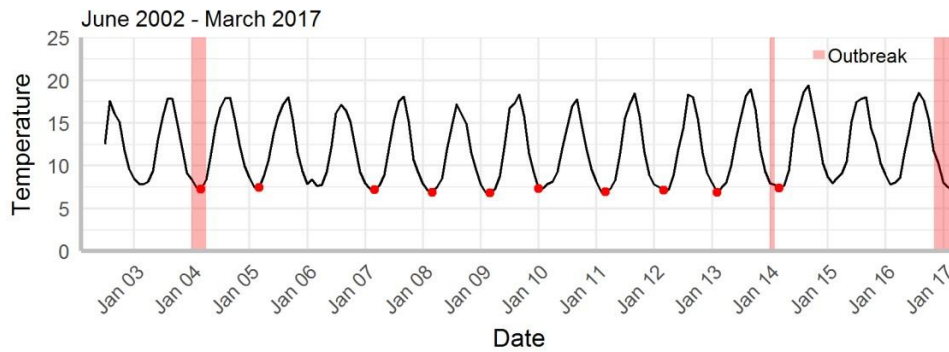
Mean daily sea surface temperature by month, West zone

January 2003 - December 2016

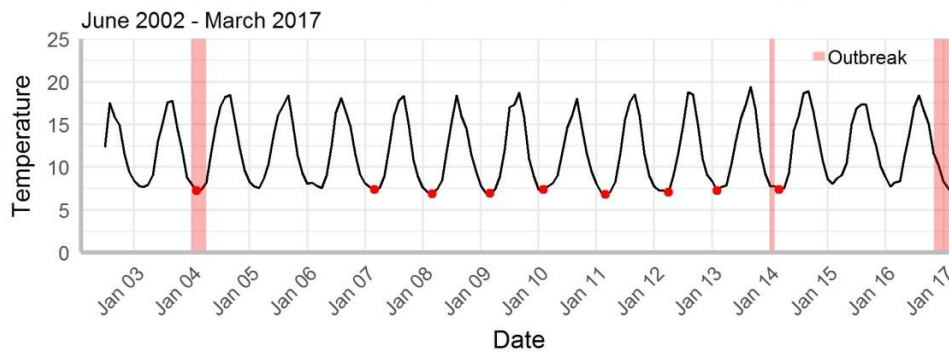


9. Max daily sea surface temperature by month

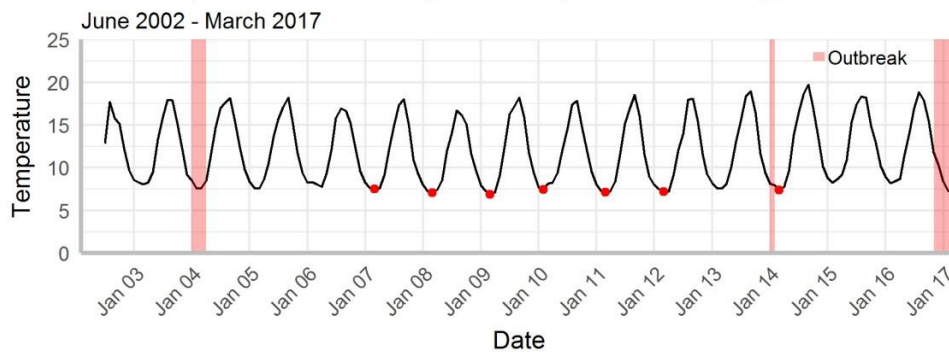
Max daily sea surface temperature by month, Baynes zone



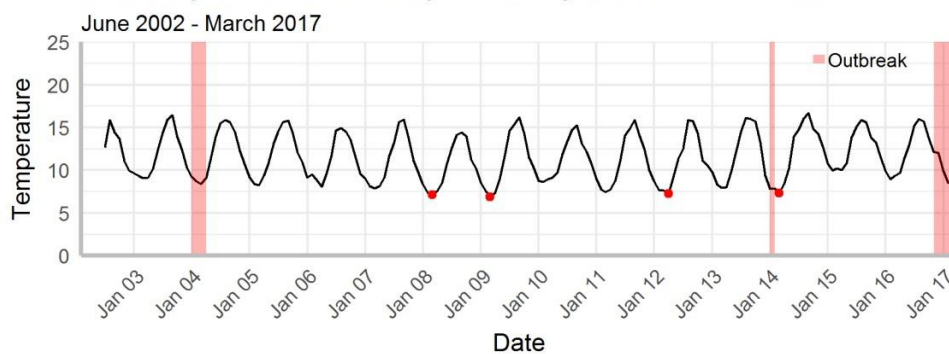
Max daily sea surface temperature by month, Quadra_Cortes zone



Max daily sea surface temperature by month, South_strait zone



Max daily sea surface temperature by month, West zone



References

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