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# Using a clustering-based approach to characterize water bodies from an autonomous underwater vehicle dataset in Monterey Bay, California

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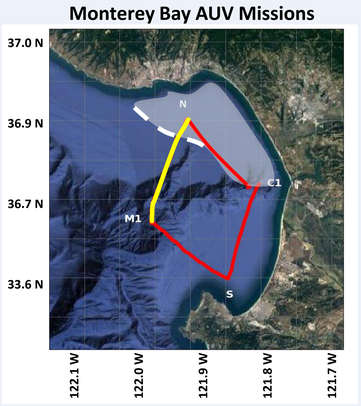
## Introduction

During periods of active upwelling, wind and local topography cause an upwelling shadow in Monterey Bay, California (Graham & Largier, 1997). This feature is separated from offshore waters by a front which is difficult to recognize due to the dynamic nature of the coastal environment and the presence of small-scale features within the frontal zone (Ryan et al., 2014). Autonomous underwater vehicles (AUVs) are efficient in these regions as they continuously capture physical, chemical, and biological parameters (Zhang et al., 2016).

**Objective: Develop a clustering method to distinguish water masses across the upwelling shadow front using a long-term AUV dataset maintained by the Monterey Bay Aquarium Research Institute.**

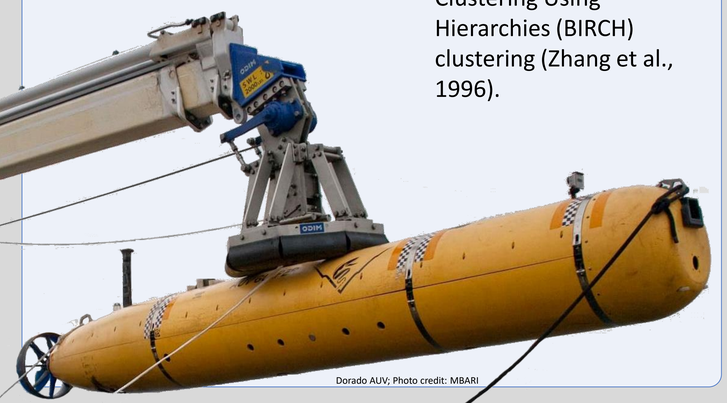
These results will be used to identify regions that covary with phytoplankton populations.

## Methods




AUV missions traverse Monterey Bay in a diamond pattern, from 2016-present.

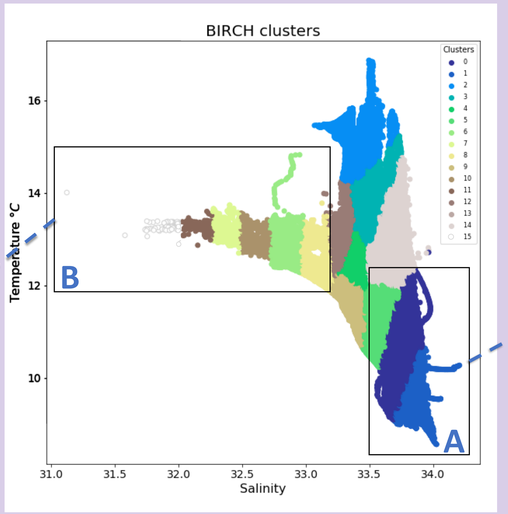
- **Upwelling shadow:** The opaque region represents the upwelling shadow, and the yellow transect between Stations M1 and N is the focus for this study as it passes directly through the upwelling shadow front (dashed line).
- **Clusters:** Plots were created using Balanced Iterative Reducing and Clustering Using Hierarchies (BIRCH) clustering (Zhang et al., 1996).



Dorado AUV; Photo credit: MBARI

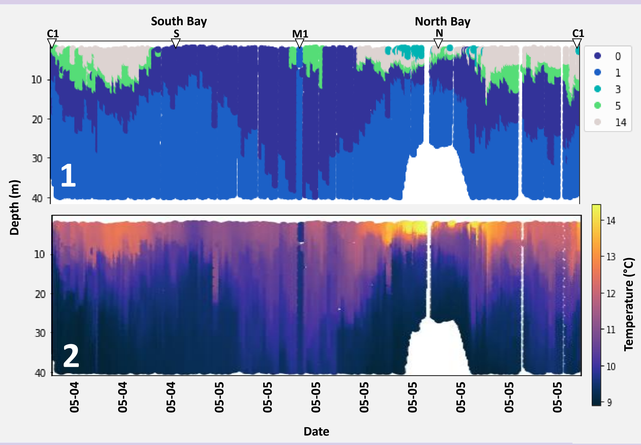
BIRCH clustering for 23 missions using temperature and salinity produced 16 unique clusters.

The warmest, freshest waters coincided with winter months (Oct-Apr).

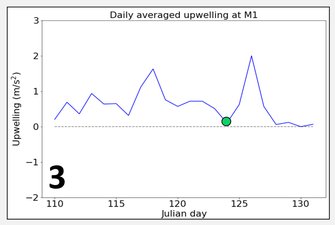



The coolest, saltiest waters appeared near the surface during summer months (May-Sept), and below 40m during the winter months (**B**).

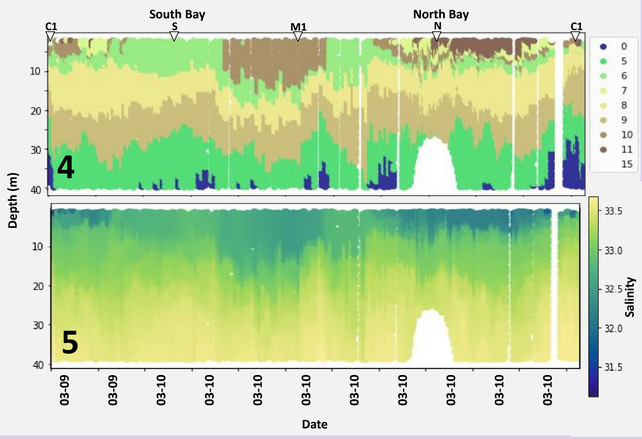
### A: Summer, May 2017



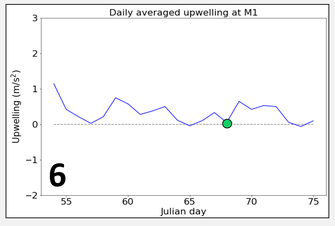

Clusters in the upper 40m (**1**) coincided with raw temperature data (**2**) in similar locations throughout the Bay. These temperatures were coincident with upwelling conditions (**3**) when upwelling-favorable winds persisted prior to the sampling date (green dot).




### B: Winter, March 2017



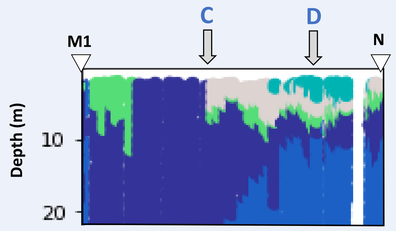

Winter clusters in the upper 40m (**4**) coincided with raw salinity data (**5**) in similar locations throughout the Bay. In the absence of upwelling-favorable winds **(6),** waters were layered, with the freshest clusters at the surface of the Bay.




## Conclusions

**Main takeaways:**

- BIRCH clustering revealed a seasonal aspect
  - Clusters 6, 7, 8, 10, 11, and 15 appeared only in the winter, likely due to seasonal rains increasing freshwater inputs to the system.
  - Clusters 0 and 1 appeared most often at the surface in the summer due to upwelling forces bringing cool, salty water from depth. During the winter, these clusters were below 40m, consistent with non-upwelling conditions.
- The clusters appear to correctly identify separate water masses with distinct temperature and salinity signatures.
  - The clusters also coincide with the upwelling shadow (**D**) and its associated front (**C**) along the M1-N transect.




**Future work:**

- These results use the AUV-recorded temperature and salinity values, but oxygen and nitrogen will also be incorporated into the water masses moving forward.
- Long-term phytoplankton monitoring at Stations M1 and N, along with eDNA from samples captured by the AUV, will be compared to the clusters to determine any covariances between water masses and phytoplankton populations.

## References

Graham & Largier. (1997). *Continental Shelf Research.* doi: 10.1016/S0278-4343(96)00045-3
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