Using California Harmful Algae Risk Mapping to Predict Sea Lion Strandings

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Introduction

- **Domoic acid (DA)** is a toxin produced by marine diatoms like those of the genus ***Pseudo-nitzschia*** **(Pn).**

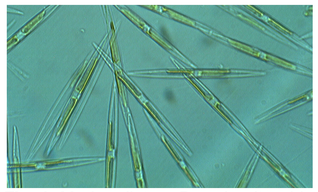

Fig. 1: Marine diatom *Pseudo-nitzschia.*

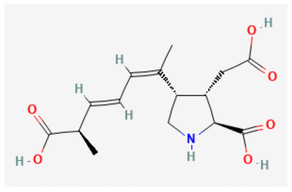

Fig. 2: Chemical structure of domoic acid ($C_{15}H_{21}NO_6$).

- DA bioaccumulates in higher trophic levels and can cause domoic acid toxicosis in marine mammals such as the California sea lion (*Zalophus californianus*), affecting their neurological systems and causing erratic behavior, seizures, and even death (Lefebvre, 1999).
- **Harmful Algal Blooms (HABs)** denote higher counts of Pn and result in higher levels of DA.
- Over recent years HABs have been occurring more often, lasting longer, and covering more area (Ruhl et. al., 2022).
- The frequency and number of sea lion strandings has increased over past years as well.
- This goal of this project is to use **California Harmful Algae Risk Mapping (C-HARM)** data to determine a variable that could be a reliable indicator that can be used to predict when and where a sea lion stranding might occur following a HAB.

Methods

- We began with data of 100 reported sea lion strandings for the year 2019, which include the coordinates of each stranding and the date it was reported.
- Geospatial and temporal scopes of the C-HARM data to be included were defined with respect to *Z. californianus* foraging and hunting behavior: males are reported to hunt and forage as far as 100 km from their rookeries, and it was estimated that it takes 2 weeks of feeding on contaminated prey and bioaccumulation after a supposed HAB for a sea lion to start exhibiting symptoms of domoic acid toxicosis (McHuron et. Al.)
- Geographical ranges and dates were entered into the ERDDAP site (Simons, R.A., 2022), then R was used to extract the corresponding C-HARM data: the area mean of cellular DA, particulate DA, and Pn for the day a stranding was reported and each of the preceding 14 days. Then a 15-day mean of each variable was calculated for each stranding from these daily means.
- Data were analyzed and modeled in a boxplot in R, and a Kruskal-Wallace test was performed for significance.

Results

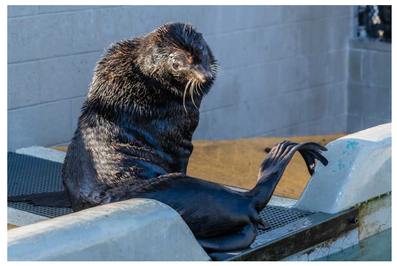

Fig. 3: A northern fur seal (*Callorhinus ursinus*) diagnosed with domoic acid toxicosis, exhibiting weakness and emaciation.

Fig 4: A sea lion foaming at the mouth, a symptom of domoic acid toxicosis.

Fig. 5: A sea lion suffering from domoic acid toxicosis.

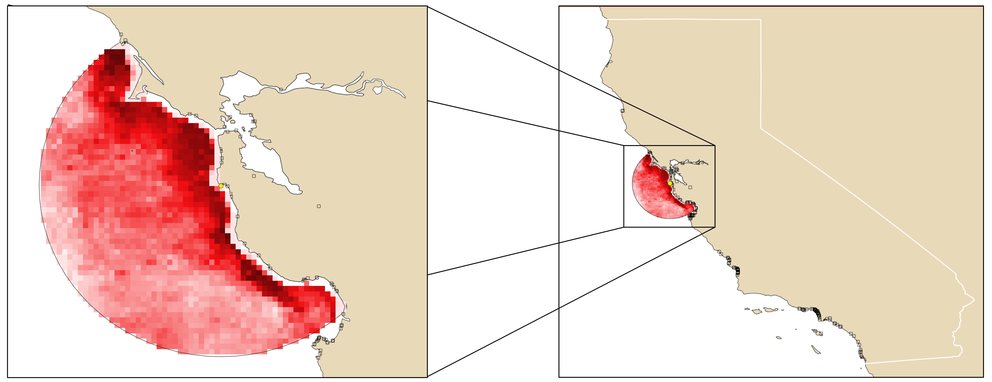

Fig. 6: QGIS sample rendering of California's coast and the probability levels of pDA (in red) within a 100 km radius of the coordinates of one selected sea lion stranding (yellow waypoint).

Variable Thresholds
cDA: > 10 pg per cell
pDA: > 500 ng per L
Pn: >10^4 cells per mL

Mean probabilities that exceed the 0.6 threshold (dashed red line) show consistent agreement between validation data and the model (Anderson et. al., 2016).

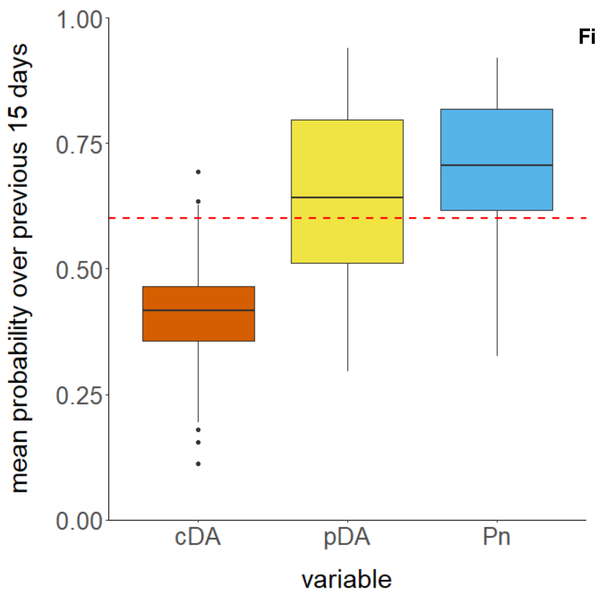

Fig. 7: Boxplot depicting the15-day mean of the daily mean probabilities that each variable will exceed its assigned threshold over the last 15 days preceding and including the day the stranding was reported. A Kruskal-Wallis test was performed on the data: **$\chi^2 = 262.24$, df = 2, $p < 2.2 \times 10^{-16}$**

Discussion

- Within the parameters defined, high probability that Pn cell count exceeds 10^4 cells per mL shows promise of being a good indicator of a subsequent sea lion stranding due to domoic acid toxicosis.
- The next steps in our research involve narrowing down the geospatial and temporal scopes to increase the accuracy with which a stranding can be predicted using C-HARM data.
- This could serve as a vital tool in marine mammal conservation in the wake of worsening HAB-related issues.

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Images

Figure 1. Microscopic view of Pseudo-nitzschia. Smith, Jason G. (Photographer). [Online Image] https://www.jcvi.org/blog/scientists-discover-genetic-basis-toxic-algal-blooms

Figure 2. Chemical structure of domoic acid. PubChem. [Online Image]

Figure 3. A northern fur seal with domoic acid toxicosis. Marine Mammal Center. [Online Image]. Retrieved from toxicosishttps://www.marinemammalcenter.org/science-conservation/research-library/domoic-acid-toxicosis

Figure 4. Connelly, L. (19 April, 2011). *Dead dolphins and sea lions along coast* [Online Image]. Retrieved from https://www.ocregister.com/2011/04/19/dead-dolphins-and-sea-lions-along-coast/

Figure 5. Segura, D. (19 April 2017). *Domoic acid affecting sea lions and other marine mammals in LA County.* [Online Image] Retrieved from https://www.dailybreeze.com/2017/04/19/domoic-acid-affecting-sea-lions-and-other-marine-animals-in-la-county/

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