Santa Rosa Island Research Station

Sensor-Based water quality monitoring of Santa Rosa Island Lagoons, 2020-2023.
2024 Report

In Collaboration with Channel Islands National Park

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1   Abstract

In collaboration with the National Park Service (NPS), the Santa Rosa Island Research Station (SRIRS) performed continuous sensor based long-term water quality monitoring of two brackish lagoons, between July 2020 and November 2023. The lagoons, referred to as Abalone Rock and Old Ranch House, are separated by approximately 845m of sandy beach/coastal habitat, on the east side of Santa Rosa Island, off the coast of Southern California. Temperature (°C) and Salinity (ppt) were measured using a mounted HOBO U24 Conductivity Logger (U24-002-C). Lagoon Depth (cm) was measured with a HOBO U20L Water Level Logger (U20L-01). Dissolved oxygen (DO) (mg/L) and pH were measured using a YSI Pro Plus during periodic sensor downloads. Lagoon areas (m^2) were determined using a Bad Elf GNSS Surveyor. Sediment fluctuation was measured using an open reel tape measure. Standard error in calculations was taken from HOBOware manuals. Temperature for both lagoons varied between 8.78-35.44 °C ($\pm$ 0.01), and salinity varied between 0.01 – 180ppt ($\pm$ 2.0). Depth varied between 0 – 1.97m and was directly affected by precipitation. pH at the Old Ranch House Lagoon varied between .07 - 9.37 ($\pm$ 0.01) and .08 - 9.29 ($\pm$ 0.01) at the Abalone Rock Lagoon. DO fluctuated between 4.10 - 9.98 (mg/L) ($\pm$ 0.01) at the Old Ranch House Lagoon and 2.99-14.03 ($\pm$ 0.01) at Abalone Rock Lagoon. While both lagoons fluctuate in size, Abalone Rock is relatively stable, the Old Ranch House lagoon can shrink by as much as 75% annually. These lagoons provide critical resources to flora and fauna, making the monitoring, and production of accurate data sets at these sites vital for the assessment of the health of Santa Rosa Island.

2   Introduction

Located on the eastern side of Santa Rosa Island there exists the only two examples of California Coastal wetlands in the Northern Channel Islands **(Figure 1)**. These lagoons, named Old Ranch House and Abalone Rock do not free exchange with the ocean and normally abstain from tidal flushing (Dugan et al. 1990). These lagoons are host to a litany of species including sea grass, various invertebrates, and fish. The lagoons serve as an important nutrient supply for avifauna such as shorebirds, raptors, waterfowl, and terrestrial birds, which depend on the lagoons for feeding grounds, hunting, and shelter for overwintering. Endangered snowy plovers nest near the lagoons (National Park Service, 2022). Mammals, including island foxes and island spotted skunks, also utilize these lagoon habitats. The lagoon sediments also host paleontological and pre-settlement artifacts, along with fossil pollen, and plant macrofossils (Rick et al. 2005)

The lagoons are vulnerable to swells and rainstorms which can change the lagoons over a short period of time. Breaking of the sand berm barrier may lead to the draining of the lagoons, consequently causing the washing of the fauna out into the ocean, or leaving other organisms exposed to the elements. This can occur in a single tidal cycle. The salinity levels of the lagoons may be altered by large waves, which could potentially also deliver to the lagoons fish and other organisms. These lagoons serve as a vital source of prey and nutrients to the surrounding ecosystem justifying the requirement for long term continuous monitoring to support the health of the surrounding areas.

3   Methods

Over the period of July 2020 to November 2023, SRIRS deployed 4 water quality loggers from HOBOware into Abalone Rock Lagoon, and Old Ranch House lagoon located on the east side of Santa Rosa Island. Two separate types of loggers were used, with U24-002 taking measurements for temperature and salinity, and U20L-1 taking measurements for temperature salinity and depth **(Figure 2)**. One of both types of loggers were deployed in both lagoons with loggers located at Old Ranch House given the name code "A", and loggers in Abalone Rock "B". Logger names are summarized in **Table 1**. The loggers collected data once per hour, per day. Calibration data was taken using an YSI pro plus, and post processing calibration was conducted in HOBOware Pro software. Data was averaged using HOBOware Pro Software and used to generate daily averages**.** Area measurements were taken with a bad elf GPS (m^2). This work was conducted under permit # CHIS-2020-SCI-0004 from Channel Islands National Park.

Approximately quarterly, SRIRS staff visited both Abalone Rock, and Old Ranch House lagoons. Staff bring YSI, Base U-4 offloading shuttle, and other miscellaneous tools. Clothed in waterproof waders, staff wade into the lagoons to visit the entrenched logger housings **(Figure 3)**. Logger housings are constructed of PVC piping, attached to fence posts and secured to structural rebar. Calibration measurements are taken using the YSI pro Quatro, and logger measurements were taken using the Base u-4 shuttle **(Table 2)**. SRIRS staff cleaned and re-positioned the logger housings and often walked the perimeter of both lagoons, with distance and area measurements taken using a bad-elf GPS.

Figure 1. Geolocation of Old Ranch House Lagoon, and Abalone Rock Lagoon on Santa Rosa Island. Old Ranch House Lagoon is designated as "A, and Abalone Rock is designated as "B".

Site Name	Lagoon	Loggers	Coordinates
A001D	Old Ranch	Temperature, Salinity, Depth	119.9797169°W 33.9573846°N
A002	Old Ranch	Temperature, Salinity	119.9786858°W 33.9562980°N
B003D	Abalone Rock	Temperature, Salinity, Depth	119.9806601°W 33.9619549°N
B004	Abalone Rock	Temperature, Salinity	119.9793452°W 33.9620336°N

Table 1. Summary table of the names of the logger instruments used to measure temperature, salinity, and depth at Santa Rosa Island Lagoons, 2020-2023. Units with names beginning with "A" refer to units installed at Old Ranch house lagoon, and units with names beginning with "B" refer to units that are installed at Abalone Rock. Units with names that end with D refer to the U20L-01 water level loggers (depth), and units with names ending in a number are the U24-002 conductivity loggers.

Figure 2. U24-002 Salinity data Logger, and U20L-01 water level logger. Loggers were installed in logger housing (**Figure 3)** with two at each location. Loggers monitor parameters mentioned in **Table 1** continuously every hour. Results were calculated using HOBOware PRO software and used to generate graphs **(Figures 5-9).**
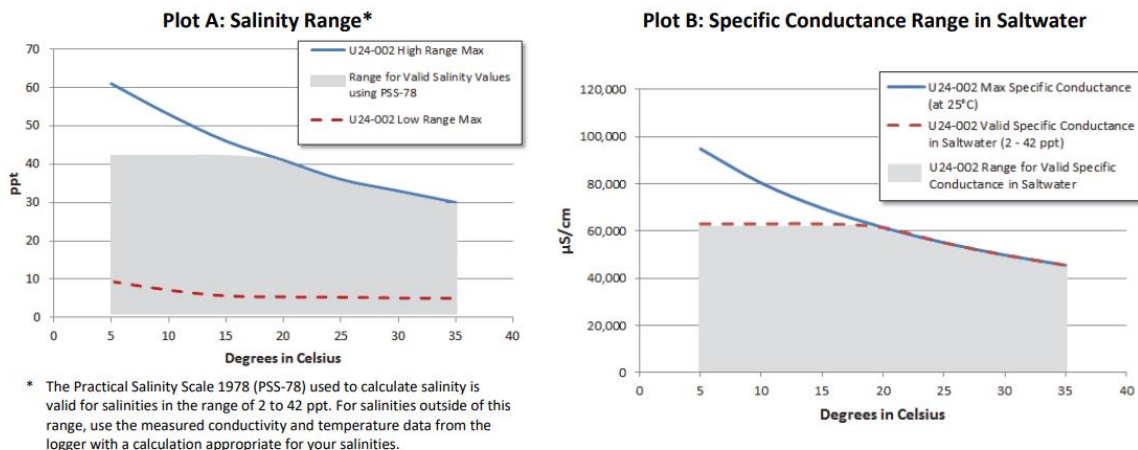
Type	Mode	Units
Area	GPS track (Bad Elf GNSS Surveyor)	m^2
Depth	Hobo Water Level Data Logger U20L-01	cm
Sediment fluctuation at logger location	Measurement to reference point	cm
Temperature	Hobo Logger, YSI pro Quatro	°C
Salinity	Hobo Saltwater Conductivity Logger U24-002-C, YSI Pro Plus used for calibration	ppt
pH	YSI Pro Plus	pH
Dissolved Oxygen	YSI Pro Plus	mg/L

Table 2. Summary of measurements, instruments, and units of measurements taken at both Abalone rock, and Old Ranch House lagoons on Santa Rosa Island.

Figure 3. Housing and mounting apparatus for logger units, and SRIRS staff removing the top of the housing to read the logger. Also pictured is the YSI unit (left hand) used for calibration measurements.

Both logger locations routinely reach levels of hyper salinity or several times ocean salinity (35ppt). Some data points were more than 2409 ppt which is impossible. These values were excluded with 180ppt set as the upper limit to include in this report. The U-24C-002-C water conductivity logger measures salinity by measuring the specific conductance of the water at 25° C. The practical salinity scale is used to calculate the salinity of the water in parts per thousand (ppt). This calculation is only valid for values between 2-42ppt. Old ranch house exceeds this range 69 % of the time, and Abalone Rock 44% of the time. To compensate and estimate more accurate and realistic salinity measurements, a linear calibration measurement was conducted **(Figure 4).** The calibration measurement is taken using a YSI pro Quatro and applied to the specific conductance of the water.

Plot A: Salinity Range*

- U24-002 High Range Max
- Range for Valid Salinity Values using PSS-78
- U24-002 Low Range Max

* The Practical Salinity Scale 1978 (PSS-78) used to calculate salinity is valid for salinities in the range of 2 to 42 ppt. For salinities outside of this range, use the measured conductivity and temperature data from the logger with a calculation appropriate for your salinities.

Plot B: Specific Conductance Range in Saltwater

- U24-002 Max Specific Conductance (at 25°C)
- U24-002 Valid Specific Conductance in Saltwater (2 - 42 ppt)
- U24-002 Range for Valid Specific Conductance in Saltwater

4   Results

Over the period of 7/20/2020-10/28/2023 over 11,500 individual data points were taken in the field and from sensor data, with some measurements that exceeded 42ppt being estimated using the methods described above. There are several gaps that occurred through the sampling process with the longest being 16 months of salinity data from logger A001 which occurred between 2.20.2022 and 6.19.2023. This gap was due to a battery failure. Logistics associated with the Covid Pandemic also impacted data consistency. There are duplicate loggers at both locations, so data was still consistent. U20L-01 depth loggers have a battery life of 5 years, and U24-002-C conductivity loggers have a battery life of 3 years. Battery replacement for the loggers requires shipping the unit to HOBOWare, this combined with the remote nature of the lagoons, and difficulty of retrieval sometimes caused loggers to fail due to battery depletion causing gaps in the data. Additionally, some loggers would be fouled by various natural forces, and would have to be replaced. Housings responsible for protecting the loggers would occasionally be destroyed by shifting silt, or biofouling.

Temperature data was taken using HOBOware sensors A001d, and B003d, separated at 2 different locations Old Ranch House, and Abalone Rock. Precipitation reached maximums on 01.28.2021 and was 2.90 cm, and 2.77cm on 03.10.2023. The islands experienced long periods of no rain, with the longest between June of 2021 and October of 2021. The islands do not typically go an entire month without any measurable precipitation, which includes fog. Annual precipitation peaks between November and March. The year 2023 has seen a marked increase in rainfall relative to the other years in this study. **(Figure 5).** Precipitation data was sourced from the Western Regional Weather Climate Center located on Black Rock Mountain on Santa Rosa (RAWS, 2023).
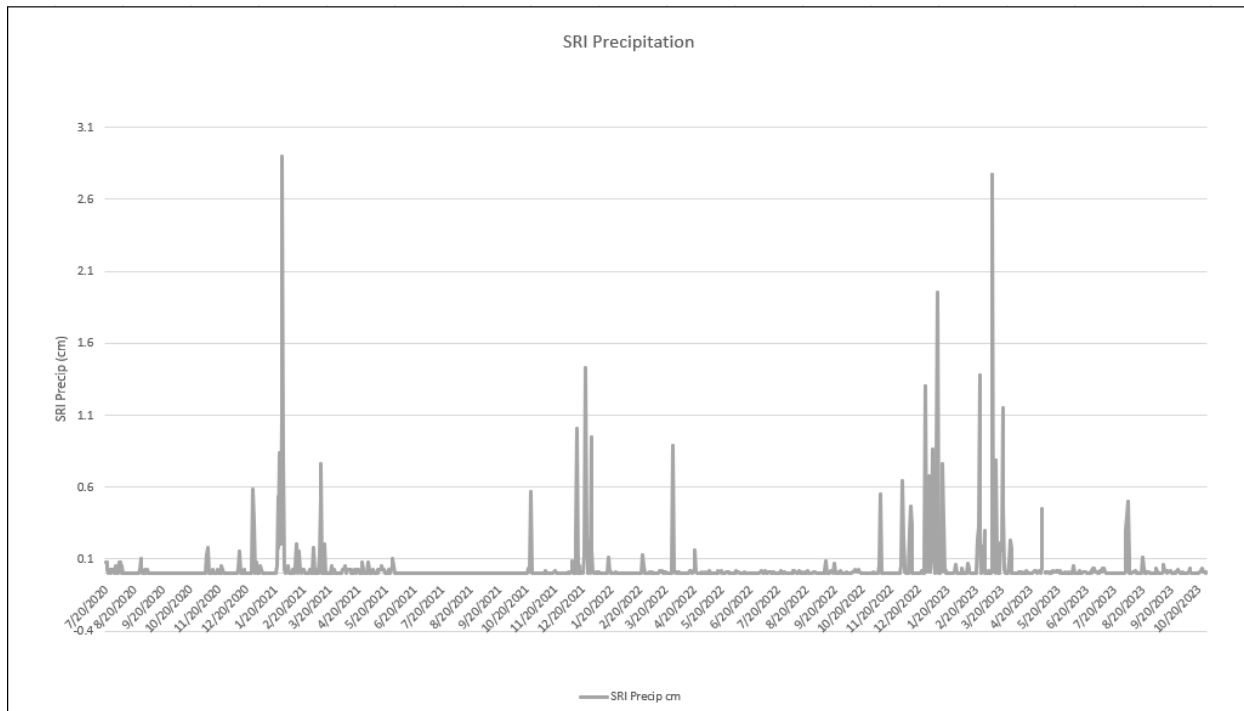
Figure 5. *Daily* Precipitation measurements (cm) on Santa Rosa Island from Jul 2020 to December 2023, sourced from the Western Regional Climate Center (RAWS , 2023)*.*
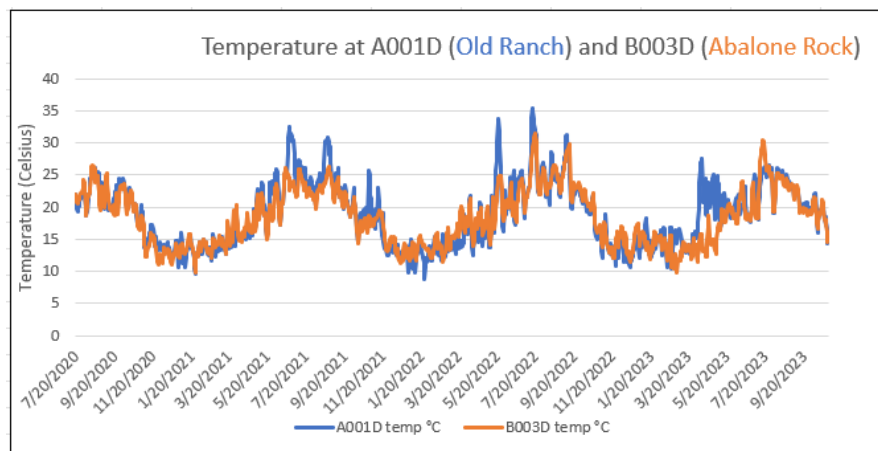

Figure 6. Temperature data (in degrees C) taken using A001d, and B003d, at Old Ranch House, and Abalone Rock. Data collection failed for B003 during 5.20.2023 offload due to water damage to the YSI - no data was collected.

Temperature reached a maximum at 35.44 °C for the Old Ranch House location, and 31.38 °C for Abalone rock on 7.16.2022, and 7.20.2022. The minimum temperature was 8.78 °C for Old Ranch House, and 9.76 °C for Abalone rock on 1.26.2022, and 1.20.2021. The temperatures of the lagoons generally remained consistent across years over this study period with peak temperatures occurring between June-August with July being the warmest month. The temperatures were at the lowest between October through March. There was a slight increase in overall temperature from the periods of 2020-2022 with temperatures beginning to decline in 2023 (**Figure 6**).

Depth reached a maximum for A001D on 12.30.2021 and was 1.62m. Maximum depth for B003d occurred on 1.5.2022 and was 1.97m.   Minimum depth for A100d occurred on 12.16.2020 and was 0.01m. Minimum Depth for B003D occurred on 4.29.2023 and was 0.11m. Depth fluctuates at both sites directly with precipitation. The largest increase in the depth of Abalone Rock lagoon occurred in conjunction with the largest precipitation event that occurred in January of 2021. Lagoons shift in depth with Abalone Rock being deeper until 2022 at which point Old Ranch House became deeper **(Figure 7)**. Depth data for Abalone Rock ceased after 7.20.2022 as both loggers failed due to batter depletion or failure.
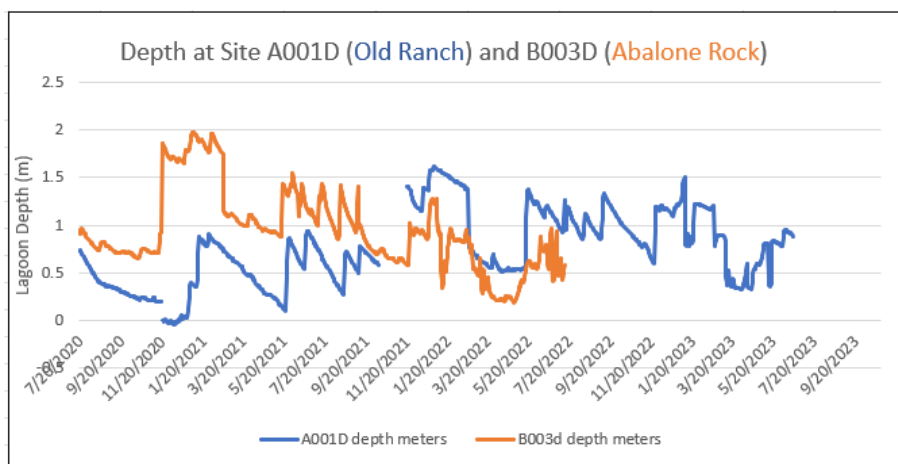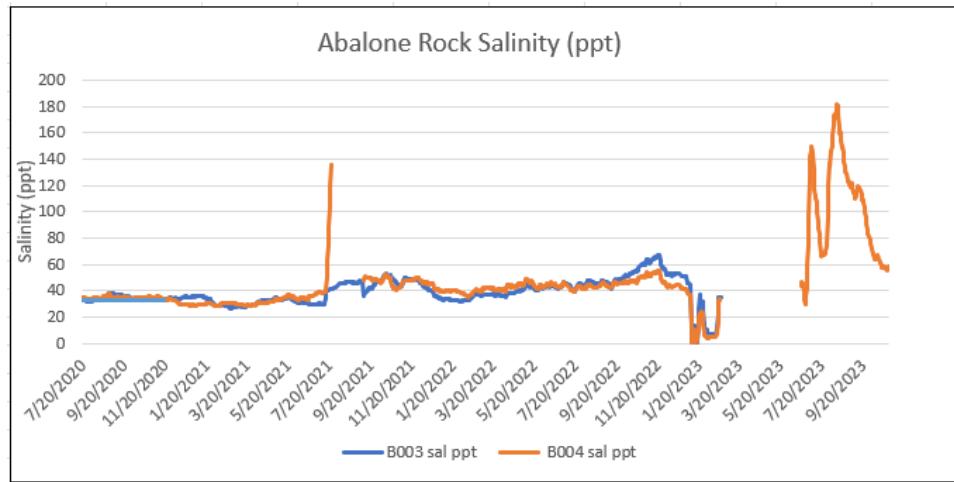

Figure 7. Depth data taken using sensors A001d, and B003d, at Old Ranch House, and Abalone Rock. Depth data fluctuated with precipitation. Data collection failed for B003 during the 5.20.2023 offload.

Salinity reached a maximum at Old Ranch House on 5.20.2021 and was 143.20 ppt. Old Ranch House reached a minimum value of .0123 ppt on 11.20.2020. Abalone Rock reached a maximum salinity of 164.73 ppt on 2.24.2023, and a minimum value of .6504, on 1.16.2023. Salinity varied greatly at Old Ranch House, indicating tidal exchange between the ocean and the lagoon. Abalone Rock remained consistent with singular salinity spikes in 7.20.2021. Salinity trends downward in both lagoons for the year of 2023 as precipitation reached a maximum. This trend was most drastic in Abalone Rock, where there was a sharp decline during September through March, and then a sharp increase from July to September.
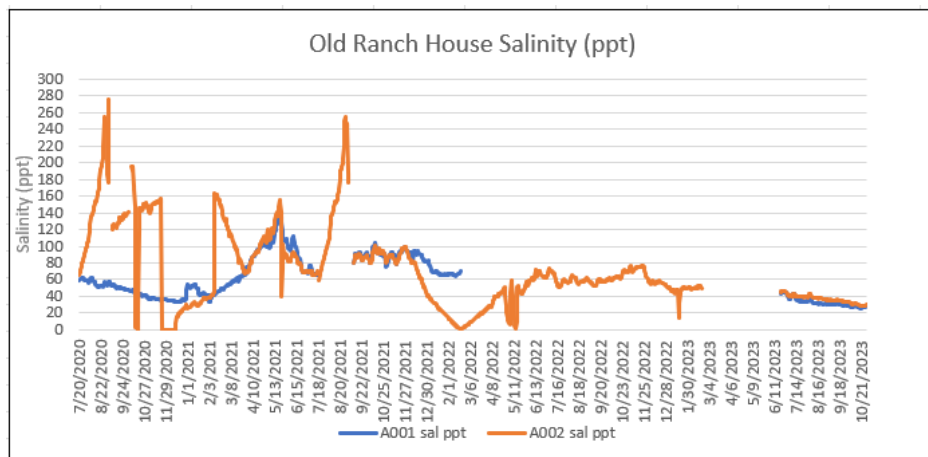
Figure 9. Salinity data taken using HOBOware sensors B003, and B004, at Abalone Rock Lagoon. Salinity displayed an inverse trend with precipitation.

Area measurements at Abalone Rock Lagoon remained relatively consistent with a starting surface area of 5,518 m^2 on 7.19.2020 and increased to 6,070 m^2 on October 28, 2023, a 9.1% increase in size. The measured surface area of Old Ranch House Lagoon fluctuated dramatically throughout the study (**Table 3**). Starting surface area was 15,340 m2 on July 19, 2020, and then dropping to 3,702 m2 on October 9, 2021, a 75.9% decrease in size.

Abalone Rock area measurement					
Date	7.19.2020	10.9.2020	11.21.2020	2.28.2021	10.28.2023
Area m^2	5518	4729	5761	3700	6070
Old Ranch House area measurement					
Date	7.19.2020	9.1.2020	7.17.2021	10.9.2021	11.20.2021	10.28.2023
Area m^2	15340	4500	20200	3702	6100	14569

Table 3. Area measurements taken at both Abalone Rock and Old Ranch House lagoons. Measurements were taken by walking the perimeter of the lagoons with a Bad Elf GPS unit.

5 Discussion and Conclusion

Both Abalone Rock, and Old Ranch House lagoons were successfully monitored for a 3-year period. Loggers in both locations experienced bio fowling and battery issues which necessitated their replacement and caused data gaps. During the 5.20.2023 offload the rubber seal in the YSI Pro unit

failed leading to water damage that prevented calibration, and consequently data offload for that period. Results indicated that both lagoons' salinity is directly correlated with the amount of precipitation that falls on the Island. Both Lagoons had salinity measurements significantly higher than ocean salinity (35 ppt), with Abalone Rock displaying a single peak where salinity reached a 3x's ocean salinity during July of 2021. Abalone Rock lagoon has been observed to be partially fed by the ocean and is most likely the reason for its similarity of salinity to ocean salinity. Old Ranch house was suspected to be ocean fed as well, but our data suggests that the lagoon is isolated from both fresh water and saltwater flow for significant portions of the year. Old Ranch House reached hyper salinity levels for much of the year, with wild fluctuations reaching 6x's ocean salinity, before dropping below ocean salinity during a period of heavy rains in February of 2022. The temperature is close between both lagoons with Abalone Rock being slightly cooler. Abalone Rock is slightly deeper than Old Ranch House, most likely causing their minute difference in temperature. Both lagoons represent a crucial source of nutrients for the surrounding area and represent a unique ecosystem on the Channel Islands that should continue to be monitored.

6 Literature Cited

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