BETWEEN the TIDES

Friends of Fitzgerald Marine Reserve

June 2023

A Brief History of Paralytic Shellfish Poisoning in California

by Gregg Langlois

The torrential rain responsible for the Great Flood of 1862 had ceased by May, and other events captured people's attention. The front page of the August 14 Daily Alta California newspaper was dominated by dispatches from the various battlegrounds of the Civil War. Amidst the telegraphed stories of "Morgan's Raid into Kentucky" and "Union Victory at Cumberland Gap," column one on the front page reported on the brief vacation of an average San Francisco resident: *"On Sunday last, Mrs. Emily Henrietta Baden, of this city, visited the lighthouse at Point Bonita, to pass a few days with some of her friends. At breakfast, on the following morning, (Monday) she ate heartily of mussels, and three hours afterwards was dead."*

Over the next 60 years sporadic mussel poisonings of unknown cause would occur at various locations. Persistent, unsubstantiated theories on the cause ranged from mussels contaminated with copper from the rocks or boat hulls, to the harvest of mussels above the water line that were suspected of containing ptomaines (substances thought to cause food poisoning from decomposition), to polluted water and spawning.

Following a 1923 clam poisoning in Humboldt County, the Healdsburg Tribune reported that local Native Americans were familiar with the risk of clam poisoning, it being a tradition not to gather clams when the 'light shows on the ocean.' The newspaper described the light as "phosphorescent, caused by minute organisms of the sea coming to the surface at certain times of the year."

Little investigation occurred in these poisonings until 1927. On July 16, the S.F. Examiner reported that, within an hour of eating mussels from the San Mateo coast for lunch, members of two families were sick and by the evening a man and his infant son were dead. More poisonings were reported in subsequent days, the majority from San Mateo mussels. The final toll was 102 poisonings and six deaths between Monterey and Sonoma counties. The state health department issued a warning against mussel harvest and forbid the sale of mussels. A regular seasonal quarantine was soon to follow.

Mussel bed along the coast

Researchers from the G.W. Hooper Foundation, U.C. San Francisco, investigated this outbreak and reported the following: symptoms could occur within minutes, including peripheral paralyses such as a tingling of the lips and tongue, progressive numbness of the extremities, loss of muscle function in the neck and extremities, difficulty breathing, and death by asphyxiation; deaths occurred within 3-10 hours; cooking did not destroy the toxin; poisonings were preceded by rough weather and northerly winds, with a sudden shift to southerly winds on July 13 and the return of northerly winds on July 17; illnesses were associated with mussels harvested July 14-17; many victims saw phosphorescence in the water, and researchers noted that coastal Pomo tribes posted sentries to look for bioluminescence, avoiding mussels for two days when present; and the common theories on poison sources were dispelled (mussels taken low in the intertidal were more toxic than those higher up). The researchers recommended continuous observations and further chemical studies to solve the

continued on page 3

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Friends of Fitzgerald Marine Reserve

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Spring Sunday Morning

2nd in the series, Celebrating the Seasons at Fitzgerald Marine Reserve by photographer Brody Scotland (BrodyQ.com)

Letter to the Editors

I love *Between the Tides!* This most recent issue was great, with Angel's inspiring life story and Rebecca's gorgeous photos. Thank you, Dan Gluesenkamp, Ph.D., California Institute for Biodiversity

Land Acknowledgment Statement

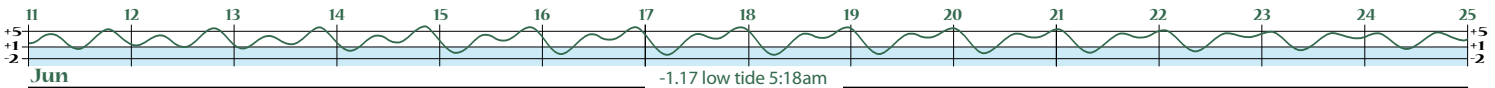
The Friends of Fitzgerald Marine Reserve acknowledges that the Reserve is located on the unceded ancestral homeland of the Ramaytush Ohlone Peoples. As guests, we recognize that we benefit from the beauty and diversity of this land and seashore. We wish to pay our respects by acknowledging the ancestors and relatives of the Ramaytush community and by affirming their sovereign rights as First Peoples to govern their communities and preserve their cultures. Finally, we seek to honor the Ramaytush community's sacred relationship with ocean and marine ecosystems by educating the Reserve's visitors and protecting the Reserve for future generations.

The graph displayed across the page bottoms shows tides for 6/11/23 to 10/29/23 at Princeton Harbor. Where the date appears is midnight. Reefs are accessible for exploring at low tides during hours when FMR is posted as "Open." Low tides at least +1 or below are best for tidepooling. See: https://fitzgeraldreserve.org/lowtides

Good low spring/summer tides are in the early morning. They change to evening tides in September. There are almost equally low tides several days before and several days after the noted low tide dates.

The lowest tides this period at Princeton Harbor:

-1.17	6/17	5:18am	-.99	8/30	4:51am
-1.78	7/4	6:22am	.92	9/18	7:40pm
lowest of 2023			-.43	9/27	3:38am
-.82	7/16	5:04am	-.35	10/1	7:08pm
-1.49	8/1	5:17am	-.12	10/18	8:09pm
4th lowest of 2023			-.78	10/28	5:17pm
-.38	8/14	4:42am			



Paralytic Shellfish *continued from page 1*

puzzle of paralytic shellfish poisoning (PSP). Thus began California's PSP Monitoring Program, the first in the U.S.

Subsequent investigations revealed: (i) all poisonings occurred between May and October; (ii) a new (in 1927) species of dinoflagellate, *Gonyaulax catenella* (now *Alexandrium catenella*), was associated with high toxin levels in mussels. The Hooper researchers detected PSP toxin in plankton samples and pure cultures; (iii) many dinoflagellates bioluminesce so, while not a reliable predictor of toxicity, it is an indicator of dinoflagellate abundance and perhaps optimum conditions for *Alexandrium*; (iv) the toxin, finally purified in 1957 and named Saxitoxin (STX), has at least 24 analogs, each with a different specific toxicity. (v) STX and analogs block sodium channels in neuronal and muscle cells, preventing nerve transmission; and (vi) there is no antidote. The extreme potency of these neurotoxins led to the Organization for the Prohibition of Chemical Weapons listing STX and analogs as a Schedule 1 intoxicant, which is strictly regulated.

Environmental research and monitoring over the years has provided more insight into the conditions associated with PSP events: (i) diatoms are more common during periods of upwelled colder water, while dinoflagellates prefer warmer water associated with upwelling relaxation and downwelling; (ii) increases in shellfish toxicity can be sudden or gradual. Sudden increases have sometimes been associated with increasing southerly winds (downwelling) that transport warmer offshore water containing dinoflagellates onshore, as observed in 1927. Gradual increases in toxicity may be related to production of vegetative cells from local cyst beds. Decades of monitoring by the California Department of Public Health (CDPH) confirmed a strong seasonal relationship for PSP events, with peak toxicity in early spring and mid-summer when relaxation of upwelling may occur (Figure 1; note the federal alert level is 80 micrograms STX per 100 grams of tissue).

As the PSP Monitoring Program transitioned from the Hooper Foundation to CDPH, local county and city agencies began submitting monthly mussel samples. San Mateo County has a long history of involvement (Figure 2), with the Fitzgerald Marine Reserve providing samples from Moss Beach in the 90s and the County Environmental Health Department currently sampling several locations. Sampling efforts expanded to include citizen volunteer samplers. CDPH performs all toxin testing, conducts additional shellfish sampling, issues health advisories and an annual mussel quarantine (May 1 – October 31), and closes commercial shellfish harvesting as needed.

PSP events continue to be unpredictable and highly variable from year to year (Figure 3). Routine shellfish monitoring and the annual quarantine remain the most effective means of public health protection. In 1991 CDPH initiated a statewide volunteer-based phytoplankton monitoring program, the first in the nation, in response to the appearance of a new neurotoxin, domoic acid. Both efforts will be reported on in future articles. For more information: https://www.cdph.ca.gov/Programs/CEH/DRSEM/pages/emb/shellfish/marine-biotoxin-monitoring-program.aspx ◆

About the author: Gregg Langlois managed the California Department of Public Health's Marine Biotoxin Monitoring Program for 28 years. He has an M.S. in marine ecology that included frequent trips to the San Mateo coast. He joined FFMR in 2022 and is enjoying the opportunity to explore and share the intertidal with students and visitors.

Figure 1

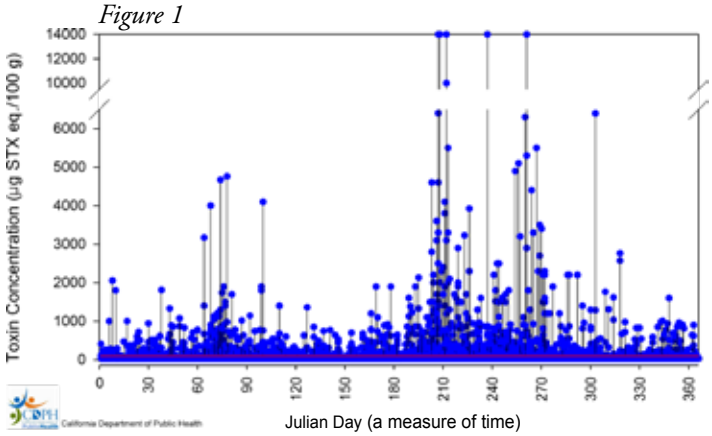


Figure 2

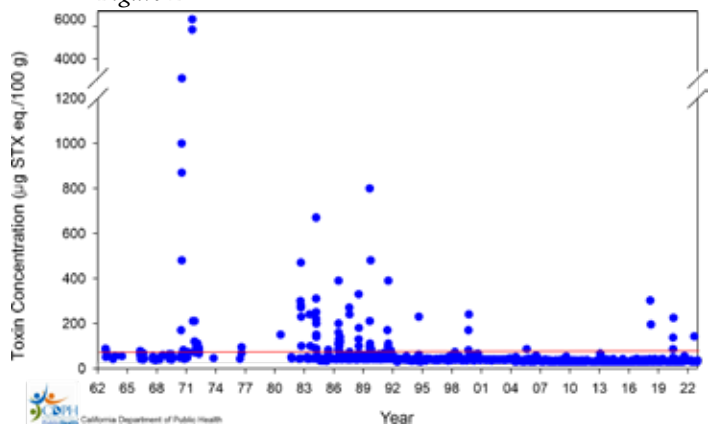
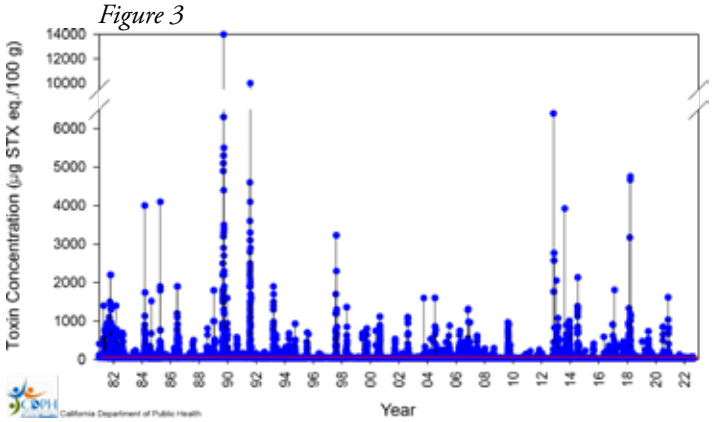
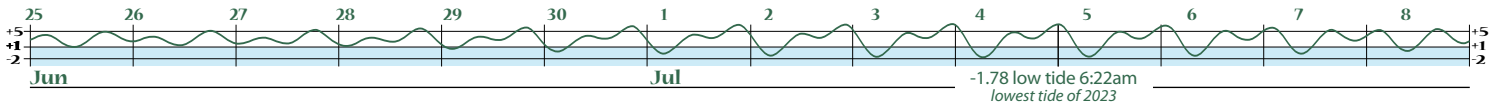


Figure 3





Two Years of FFMR Research Surveys

by Karen Kalumuck

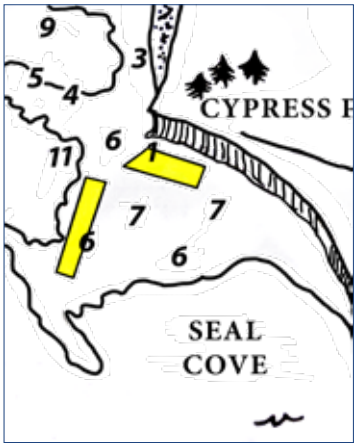


Figure 1. Diagram of Research Sectors highlighted in yellow. Sector 1 is the upper right trapezoid, and Sector 2 is the rectangular area (not to scale).

"Why are there so many Sunburst Anemones at FMR now, when there didn't used to be any?" "Are seastars making a comeback at FMR?" "Are new invasive species becoming established on the reef?"

"Why" questions, such as the first one above, are challenging to answer and require extensive scientific study. Questions about the presence, absence, or numbers of individual organisms can be addressed by Citizen Scientists. By repeatedly using the same methods of identification and counting of organisms, a census of the organisms in a particular sector can be developed. These defined "baselines" of who and how many live in an area can be used as a starting point for long term comparisons of ecosystem changes potentially related to climate change and extreme weather events such as drought.

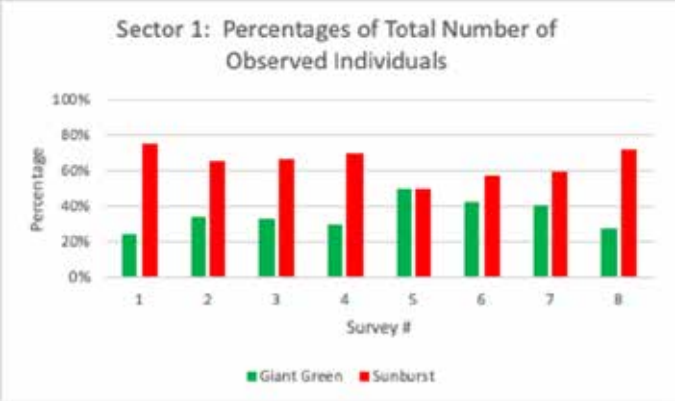


Figure 2. Giant Green Anemones (Anthopleura xanthogrammica) *vs. Sunburst anemones* (Anthopleura sola) *in Sector 1.*

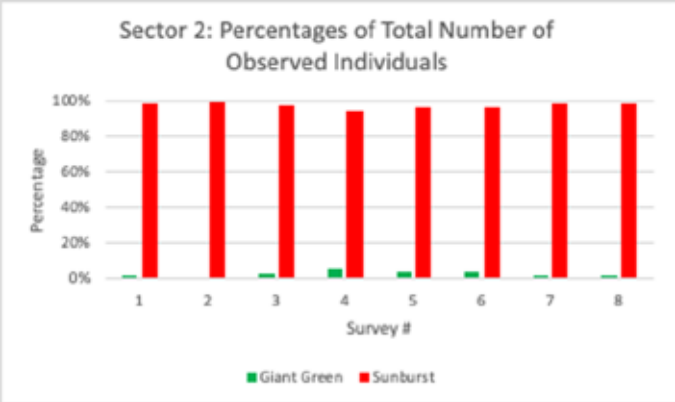


Figure 3. Giant Green Anemones (Anthopleura xanthogrammica) *vs. Sunburst anemones* (Anthopleura sola) *in Sector 2.*

History of the Research Surveys

During the closure of FMR due to the Covid-19 pandemic, a group of FFMR volunteer naturalists submitted a proposal to San Mateo County Parks department, and were awarded a Scientific Permit for two years of work. The goal of the proposed quarterly Research Surveys by FFMR was to gather enough data to establish a baseline population of select organisms in specified sectors. The Research Sectors chosen were an upper to middle intertidal area initiated at Cypress Point, and a long deep channel encompassing mid to lower intertidal (Figure 1). We chose to monitor numbers of *Anthopleura xanthogrammica* (Giant Green anemone) and *Anthopleura sola* (Sunburst Anemone), all sea stars and nudibranchs, and to note any invasive or unusual species or disease symptoms of any of the target organisms.

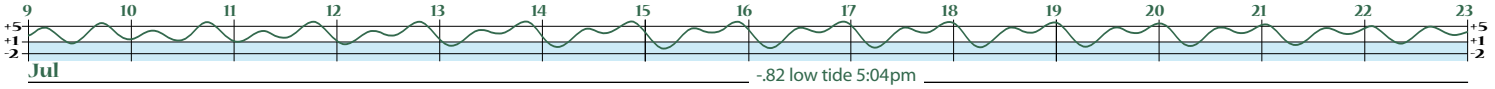
What follows is a brief summary of some of the highlights from our work.*

Highlights— A. xanthogrammica vs. A. sola

Twenty-six FFMR volunteers conducted eight quarterly surveys, from February, 2021 through December, 2022. Over the course of the surveys, small numbers of healthy sea stars were observed in each Sector, as was the occasional nudibranch. No invasive species were observed. The census of the two species of sea anemones provided the most significant and surprising data.

In each Sector, A. sola was the dominant species found (Figures 2 and 3). While the two species could exist in similar numbers in Sector 1, the near absence of *A. xanthogrammica* in Sector 2 was striking. Numbers of *A. xanthogrammica* in this sector ranged from zero to four, while those of A. sola routinely exceeded 100.

We have no data that describe the historical presence of *A. xanthogrammica* anywhere at FMR, so cannot speculate on the role *A. sola* may have had on any *A. xanthogrammica*. Indeed, *A. sola* is known to be ➥



Spotlight on Alison Young, New FFMR Board Member

Alison is the Co-Director of the Center for Biodiversity and Community Science at the California Academy of Sciences. In this role she builds community and partnerships around nature and sharing knowledge about biodiversity, creates events and campaigns focused on documenting species, and brings this community-collected data to answer scientific questions and help inform decision-making. As part of this work, Alison leads the annual City Nature Challenge, one of the largest community science events in the world, collaborating with people around the globe to share biodiversity observations in and around urban areas.

She is also involved in running Snapshot Cal Coast, a yearly campaign to mobilize the public to document species along the California coastline. (See the article about Snapshot Cal Coast and photos of the top 25 most observed species from San Mateo County, 2022 in *Between the Tides*, December 2022.)

Alison is co-director of the Academy's Thriving California strategic initiative, focused on scaling biodiversity science and education, and collaborating with communities, other organizations, and the state, to build a healthy, resilient future for people and nature in California.

Alison's background is in marine biology. She holds a Masters in Biology from Humboldt State University for research focused on the potential effects of climate change on California's rocky intertidal communities, and a B.A. in Biology from Swarthmore College. Between her undergraduate and graduate programs, she spent six years teaching Environmental Education to fifth and sixth graders at outdoor schools in the Santa Cruz Mountains (and worked various other jobs in the summers, including being a seasonal Interpretive Naturalist at Memorial Park). Prior to working at the Academy, Alison worked for the Greater Farallones Association, running the LiMPETS* program. (See *Between the Tides* Sept. 2012 and March 2013.)

It was during her tenure with LiMPETS that Alison regularly started visiting the Fitzgerald Marine Reserve, and through her work at the Academy she's helped to host numerous bioblitzes in the FMR tidepools (including one bioblitz that led to an interesting mystery about a Wolf Eel head, https://www.youtube.com/watch?v=Pl2xQg_cRcM)

She's also been working with volunteers just down the coast at Pillar Point for over 10 years now to conduct long-term monitoring and to build a species atlas of the reef.

Most recently she helped the San Mateo Marine Protected Area Collaborative start a stewards program to share information with visitors about sustainable harvesting and to inspire curiosity about tidepool organisms.

She's excited to join the FFMR Board to help build connections between science, education, and conservation opportunities along the coast and throughout California with the work of FFMR and what's happening at the reserve.

When she's not in the tidepools for work, Alison can often be found in the tidepools for fun, usually photographing nudibranchs, or in her local ceramics studio, happily bent over a pottery wheel, covered in clay. ◆

Wolf Eel head, photo: Alison Young

*LiMPETS (Long-term Monitoring Program and Experiential Training for Students.) This hands-on program was developed to monitor the coastal ecosystems of California's national marine sanctuaries to increase awareness and stewardship of these important areas.

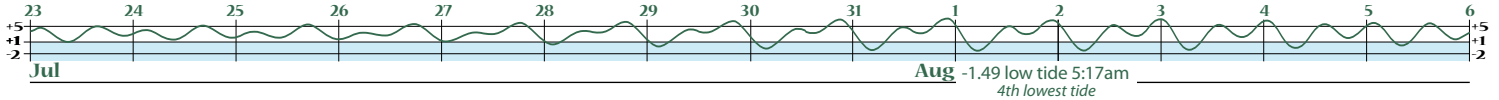
➦ an aggressive anemone, (https://www.canaturalist.com/ready-for-battle/) attacking unrelated anemones who they encounter. While these baseline data cannot answer the "how and why" questions, we do have solid census data for future survey comparisons.

What's Next?

The San Mateo County Parks Department has awarded FFMR a three-year extension on our initial Scientific Permit. With continued monitoring, we hope to document any changes in populations of our target organisms, inform appropriate officials of any potential disease detected, and monitor the arrival of new or invasive species.

**Prior articles by Karen Kalumuck regarding the Research Surveys can be found in archived editions of Between the Tides at https://fitzgeraldreserve.org/between-the-tides*

- *—March, 2021: Permitting process, scope of work, first survey findings*
- *—September 2021: Research update, including Survey #3*
- *—March 2021: Summary of results of first four surveys*
- *—June 2022; Research update, survey #6* ◆



2023 FFMR Volunteer Training Class

by Susan Evans

January, February, and March 2023 were the months FFMR would never, ever have wished for FMR. Storms not only felled trees which landed on bridges and houses, but powerful ocean waves tore away our beach access stairs and ramps. FMR was closed, opened and re-closed for weeks due to ongoing horrific storm damage. For the class, where we might previously have had four low tide explorations at Seal Cove, this year we only had one, two others at Pillar Point and one exploration rained out. The mentoring program was obviously postponed far into April.

Microscope work with Joseph Centoni, Brittany Stubbs, Megan Bowley and Jessica Eberle

Phylum games with Nora Kovscek, Eliza Frankel, Brittany Stubbs and Tara Parkman

Thank you to all our lecturers and helpers, especially Joseph Centoni who added an additional lecture day and lab at HMBHS. We used microscopes to examine harbor plankton samples (barnacle larvae were prolific) and observed external structures of echinoderms.

Several students generously offered to give their impressions of the 2023 class.

Geology Exploration

Megan's view on the class:

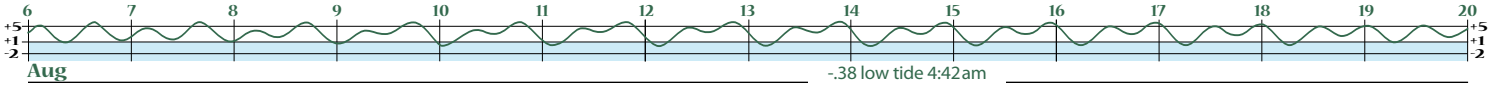
When I signed up for the 2023 naturalist class, I was really excited because I love marine life. But a part of me was really nervous because I am high functioning special needs. Ron and Susan are wonderful instructors, as were all the lecturers. They made me feel there was no such thing as a stupid question (although I felt some of mine may have been) and that everyone was equal. It was a wonderful feeling and experience. I am so glad I did this and feel this was a wonderful adventure. I would do this again in a heartbeat and would encourage anyone to do it.

From Adam (AJ):

I had a delightful time in the class preparing us for the volunteer work we are doing. I learned a ton of valuable information about the coast, tide pools, the intertidal zone, and some of the creatures that reside there. We learned about the original inhabitants of the area and what happened to them. I did not know that Fitzgerald Marine Reserve sat on the San Gregorio fault; I learned this and a ton of other details about the geology and plate tectonics of the area, and so much more.

I would not have had this opportunity if not for the hard work of Susan, her team and all the other unnamed volunteers that keep this place running. They all put together a group of knowledgeable people including a bunch of teachers. Most were college-level teachers who always left me feeling invigorated; some made me want to go back to school and study marine biology.

I took my first group out mid-April and am quite comfortable with the amount of information I was given to show them around and it really helps being able to talk about these creatures with people who are also interested. I like being around people who care, it affects me, I like to care, and it is the reason we gather at low tide in this marine reserve. We gather to protect, observe, and communicate the importance of diverse environments in one of the most effective ways possible—that is to exhibit it. So I'm happy to be here with my cohorts, to tiptoe about amongst the hermit crabs and snails and talk



about the things we often miss. Thank you for your hard work and the opportunities you have offered me. I'll see you on the reef.

From Eliza Frankel:

I am a junior in high school. I had been looking for a nature reserve to volunteer at for some time and I came across the FFMR Naturalist Training Class. I signed up not knowing what to expect, but I am glad I did! It was so amazing to be learning with people with the same passions as you. The program brought in different professionals every week to teach us about something new, and then we would go to the tide pools to use what we learned and talk about it. Being a teenager with a full set of high school classes, a job, and other extracurricular activities, it was a bit hard to adjust at first since the class became a big part of my schedule (training every Saturday from around 11-5 for roughly 3 months). However, being a current student, I was familiar with the structure of the class and knew how to study and prepare for the tests. Being in the class with people of all different ages and backgrounds, you can learn beyond what the material teaches you. Everyone pitches in with their own life experiences. You have some people who are just getting into marine biology (like me), and others who have been studying the field their whole life; and with both types, you learn so much more than you would expect. As a high school student, it is refreshing to learn from people who have different backgrounds and paths in life, yet also share the same interest in learning more. If I had the opportunity, I would absolutely take this class again!

From Emilie Campbell:

As a high school junior, my biggest worry when I came into the class was time. However, fitting in the class was not difficult, despite AP Classes, soccer, and other extracurriculars, as the reading was minimal, and it was only once a week. One of the most memorable things during the FFMR classes was the difference between the class and my normal classes. At school, the amount of people who truly care about the subject they are learning is quite minimal, taking away from the desire to be engaged. However, during this course, no one is required to be there, they want to be there, and because they want to be there, they engage in the class by asking questions or discussing personal experiences. It is truly amazing to see people of all ages and backgrounds interested in the same subjects as you, and that is incredibly rewarding.

Thank you, thank you, to ALL students for your many insightful and delightful comments. We ALL at FFMR wish you many happy years of tidepooling. ◆

Harbor underwater view

Harbor fun with tunicates and bryozoan and Eliza Frankel, Marta Fernandez and Melody Lee ('22)

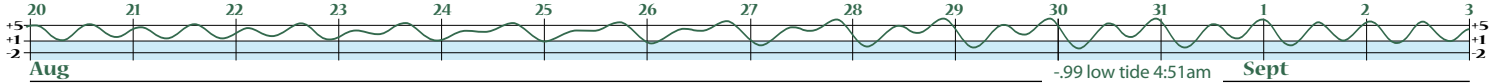
Classroom work with Nora Kovscek, Ivy Rylander, Eliza Frankel, Jessica Eberle, Megan Bowley, Marta Fernandez and Claire Tracey

Seventeen students graduated this year, including three high school students.

Congratulations to:

Gregg Berman, Megan Bowley, Marisa Burman, Emilie Campbell, Jeff Clarke, Jessica Eberle, Marta Fernandez, Eliza Frankel, Marina Fraser, Kevin Hall, Adam Johnson(AJ), Nora Kovscek, Mike Morgan, Tara Parkman, Ivy Rylander, Brittany Stubbs and Claire Tracey.

Lab work with Claire Tracey, Kevin Hall, Ron Olson, Mike Morgan and Marta Fernandez



It's All In How You Look At Things: Octopus Vision

by Tom Ciotti

At the 2022 Friends of Fitzgerald Marine Reserve Volunteer Naturalist Training Class session on mollusks, Professor Jean Replicon was discussing the amazing ability of octopuses and other cephalopods to change color to camouflage themselves or display (themselves) for others of their species. I was sitting in on that class and commented that (their camouflage) ability was surprising because octopuses were color blind—a "fact" I had learned some 10 years ago from several marine biology texts while researching octopuses. My comment was met by extensive skepticism from the class. How could these masters of color change possibly be color blind?

So I decided to take a fresh look at this paradox and found subsequent research has revealed fascinating information about how octopuses might see color. Sit back, keep reading, and be prepared to be fascinated!

…they [researchers Christopher and Alexander Stubbs] showed that octopuses may be capable of detecting and distinguishing different radiation wavelengths in an entirely different way than using multiple photoreceptors.

The Question: Can Octopuses See Color?

Based on my research I believe this question cannot currently be answered with any certainty. What I can say with certainty is if they do, they don't do it like humans.

Human eyes have three different photoreceptors that are respectively sensitive to the three different primary color wavelength groups, namely those that define what humans perceive as red, blue, and green. Having multiple different photoreceptors is what enables us to see different colors. In contrast, octopuses only have one photoreceptor and thus can't detect and distinguish different wavelengths like humans do. This led to the belief that octopuses could not distinguish different wavelength groups and could only see black and white. Hence all those old texts saying octopuses are color blind.

Red Octopus, photo: Jenna Kinghorn

But what if octopuses can distinguish different wavelength groups in a way that doesn't require multiple different photoreceptors?

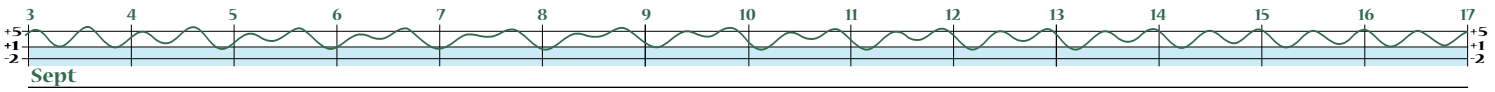
In 2016 the father-and-son research team of Christopher and Alexander Stubbs published a scientifically convincing paper postulating another way octopuses could distinguish different wavelength groups based on the anatomy of their eyes.

Octopus eyes and human eyes are similar in some ways and different in others. The differences are evolutionarily related to the different environments in which they and we live and the challenges of those environments to our and their survivals.

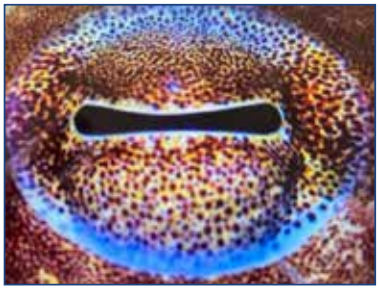
According to the Stubbs paper the differences involved in color vision involve the pupils and lenses and an optics phenomenon called chromatic aberration (CA). Humans have round pupils that contract to make light enter the lens in a single direction so that all the light wavelengths (colors) are focused on a single spot. We use our multiple photoreceptors to discriminate the different focused wavelengths. If our round pupils didn't contract, the different wavelengths would focus at different spots or focal points causing blurring and colorful fringes around objects due to CA. That is what happens when our eyes are dilated in an eye examination.

In contrast, octopus pupils are shaped like an elongated dumbbell which allows light to enter the lens in many directions and the different wavelengths to spread out and focus on different spots due to CA. This is similar to the way a prism spreads light into different wavelengths. So the human eye evolved to minimize CA whereas the octopus eye evolved to maximize CA.

The difference between the human lens and the octopus lens may allow the octopus to distinguish the differently focused wavelengths. The human lens is fixed and changes



shape to focus, whereas the octopus lens is moveable, much like the lens in a camera or telescope, and moves to focus. The Stubbs paper postulates that by moving their lens octopuses can rapidly focus on the different wavelength focal points to provide a sequence of blurring that is wavelength (color) dependent. The Stubbses created a computer model of this "octocolor vision" methodology that validated its feasibility. In doing so they showed that oc-



topuses may be capable of detecting and distinguishing different radiation wavelengths in an entirely different way than using multiple photoreceptors. Hence, the previous rationale for concluding octopuses are color blind may not be valid.

However, if octopus eyes are indeed detecting and distinguishing between different light wavelengths à la Stubbs, there is no basis to conclude that information is being transmitted to and/or processed by the octopus' brains in a manner that results in the octopus experiencing the sensation humans call color. For instance they might instead experience a sensation that is somehow wavelength correlated to color such as degrees of blurring or shades of gray. Because humans perceive different light wavelengths as color, doesn't mean that other creatures must do likewise or cannot perceive them as a different sensation.

We, of course, are still faced with the fact that according to human sensory perception octopuses are able to rapidly change the color of their skin to camouflage themselves. It certainly seems reasonable to assume octopuses use their vision sense to instigate and drive such change. Whether the sensation of color or some other sensation that is somehow wavelength correlated to color is behind the change remains to be determined. In other words, the stimulus causing the change might not be color but the change, at least to human eyes, is color.

The variation in the sensory abilities of different animals and the resulting differences in their respective perceptions of the world is complex, poorly understood, and very possibly incapable of being totally comprehended. Assessing the sensory capabilities of beings that are radically different from humans, such as octopuses, and appreciating how they might perceive the world may be impossible. If readers of this article are interested in learning more about this, I found the book *An Immense World* by Ed Yong (see page 11 for a review of this book) and recent podcasts by Roger Hanlon, an expert on cephalopod sensory ecology at the Marine Biological Laboratory at Woods Hole MA, to be interesting, informative, and intellectually humbling.

Echoing the king in the musical The King and I, my answer to whether octopuses see color is " 'tis a puzzlement." The Stubbs work shows the absence of multiple photoreceptors is not necessarily a conclusive determinant of color blindness. So we have no basis to conclude with certainty that they don't. On the other hand, we have no basis yet to conclude that the octopus vision methodology enables the octopus to perceive colors. What we do know is that octopuses can change their color extremely rapidly at will to either camouflage themselves or communicate with other octopuses. If they are color blind, they certainly don't act like it. Those nonconformist octopuses clearly did not get our message that they are color blind! ◆

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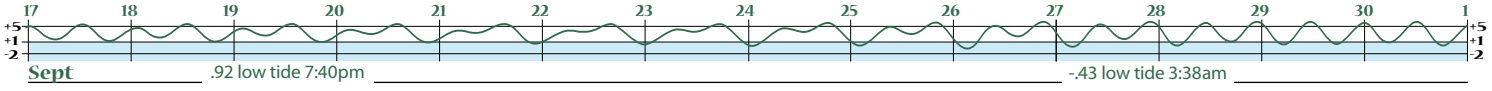
…we have no basis yet to conclude that the octopus vision methodology enables the octopus to perceive colors.

Octopi

In a footnote in his book An Immense World, *Ed Yong writes:*
There's always at least one person who writes in with a pompous and incorrect corrective, so let's get this out of the way: The word octopus is derived from Greek, not Latin, so the correct plural is not octopi. Technically, the formal plural would be octopodes (pronounced ock-toe-poe-dees) but octopuses will do.

Octopuses



President's Message

Parks, such as ours, are essential for our health and wellbeing, and I urge you to plan a visit to any of the parks that your community has to offer. You won't be disappointed.

After what seems like the longest and cruelest winter, Mother Nature is finally tempting/rewarding us with the springtime that we so truly need.

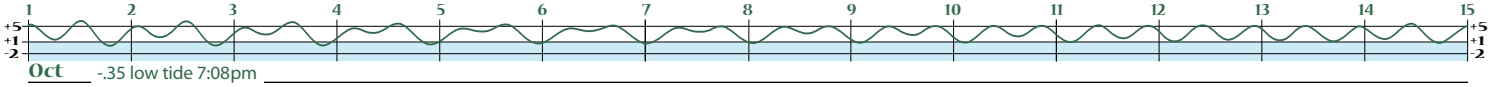
Work is progressing in dealing with the hand she has dealt us this year. Many of the fallen trees, as well as those that were threatening to cause harm, have been removed. A few of the tree stumps and crushed picnic tables will soon be cleared from the area, and we are fortunate that many things survived without any damage. Our parking lot, visitor center, ranger's office, and restrooms were all spared. Despite trees falling all around the area, our gray whale skeletal exhibit, which was put on display last year, was untouched. Our easy-access ramp near the main parking lot remains damaged but the steps down to the beach provide a safe access for visitors. The Seal Cove stairway has been fully repaired, but unfortunately the bridge at San Vicente Creek remains closed due to severe damage from a fallen tree. This not only separates visitors from the serenity they can experience along our cypress covered bluffs and hiking trails, but it also makes Seal Cove accessible only from neighborhoods that border the south end of our park. Luckily, school group tours have resumed, with many visitors taking advantage of all the area has to offer.

Although the current situation can prove to be frustrating for us all, it is important to remain respectful and courteous of our neighbors and fellow visitors. While the beauty of our park remains, our ability to freely explore its wonders will remain hampered until the restoration projects are completed.

There is hope on the horizon. With a little luck and a lot of hard work it is possible that the new bridge will be in place sometime this fall. Parks, such as ours, are essential for our health and wellbeing, and I urge you to plan a visit to any of the parks that your community has to offer. You won't be disappointed. ◆

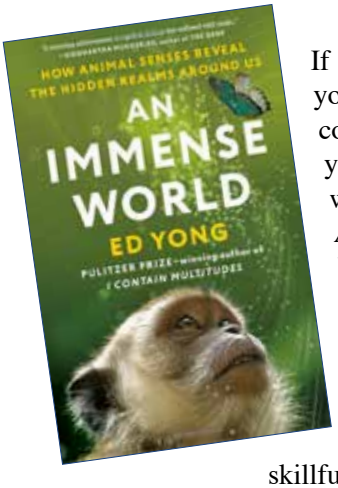
Damaged Seal Cove stairs, photos: Rob Cala

Repaired Seal Cove stairs, photo: Martie Sautter



An Immense World

by Ed Yong, reviewed by Jody Stewart



If you think the world you live in today is complicated, wait until you read Pulitzer Prize winning Ed Yong's book, *An Immense World*. Yong promises to take us outside our sensory bubbles and into the hidden realms around us. He does not disappoint. Yong skillfully, and with good humor, invites us to an earth that "teems with sights and texture, sounds and vibrations, smells and tastes, electric and magnetic fields," most of which we are unaware of but which exist in abundance. Giving us insights into the sensory world of an array of animals, Yong invites us to, momentarily, step outside our own sensory bubble. Did you know the paws of a sea otter are so sensitive that they can feel for their prey, distinguishing between different textures to find their next meal, that spiders, who have poor eyesight, focus on their web, oblivious to the wider world around them, reacting to vibrations as insects get trapped in their gossamer creations, and that turtles track the earth's magnetic field to navigate their world?

It is not the physicality of the discussion that Yong is inviting us to so much as giving us insight into animals' sensory bubbles, the *Umwelt*—the part of their surroundings that an animal can sense and experience—its perceptual world." Each animal species has a different perceptual world that it navigates throughout its life. For example, giant squid have evolved to have eyes the size of soccer balls, not making their vision sharper but allowing them to see large glowing objects in deep water, specifically the sperm whale (or more specifically the cloud of bioluminescent plankton that it ignites as it dives), one of the few predators the squid has.

Yong has found the perfect balance between presenting scientific facts and storytelling. If I had been fearful this would be an overly scientific text, full of jargon and dry in the telling I was wholeheartedly wrong. Occasionally, when I thought we might be wandering a little beyond my comfort zone, Yong pulls back, offering another fascinating insight, connecting the stories, prompting me to keep reading.

Each chapter focuses on a different sense. I particularly appreciated the final Chapter, "Save the Quiet, Preserve the Dark," where Yong delves a little into how human behavior changes animals' sensory bubbles, how we disrupt the natural world and animals' Umwelt with street lighting and noisy shipping lanes among other things. He's not preachy, he just gives us the facts, encouraging all of us to, occasionally, look at the animal world differently.

This book is not about comparisons, one animal to another or anthropomorphizing animal sensory bubbles in relationship to humans. It is about pausing for a moment, maybe on the reef, looking down and seeing an animal and imaging, just for one moment, what they are sensing, what their sensory bubble is in the moment. At the very least it introduces you to a fun new way to look at the animal world. This is an entertaining, well researched, and well written book. ◆

About the reviewer: Jody lives in Half Moon Bay and has been a volunteer at the FMR since 2018. Originally from New Zealand she has lived in the United States since 2006.

Did you know… that turtles track the earth's magnetic field to navigate their world?

We need to stop asking "How good is an animal's sense of smell?" Better questions would be "How important is smell to that animal?" and "What does it use its sense of smell for?"

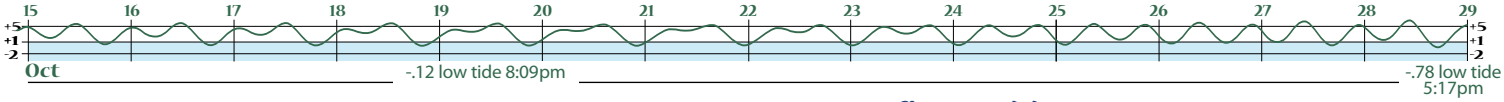
photo: Gunn Shots !

photo: Mathias Appel

photo: Artur Rydzewski

photo: Sonke Johnsen

L to R: the side-facing slits of a dog's nostrils allow its exhalations to waft more odors into its nose; Catfish are swimming tongues, with taste buds dotted all over their skins; a jumping spider's central eyes offer sharp vision, while the pair on the side track movement; the bay scallop has dozens of bright blue eyes along the rim of its shell. From An Immense World *by Ed Young.*



Typo the corgi is modeling the difference between the trichromatic color vision of (most) humans and the dichromatic vision of dogs.

More images from An Immense World by Ed Yong

photos: Typo the corgi: Ed Yong, bottom photo created using the Dog Vision Tool by András Péter; chameleon: VVillamon; butterfly: Tambako the Jaguar

A chameleon can look forward and behind simultaneously with its independent eyes.

With receptors on their feet, butterflies and other insects can taste things by landing on them.

Tidepool Quiz

The questions below have been taken from different issues of Between the Tides.
Circle your answer to each question then check your score with the answers listed underneath.

1. The most common tidepool fish is: eel, cabezon, sculpin, rockfish.
2. Most red tides are caused by: flagellates, upwelling, blue-green algae, dinoflagellates.
3. A tidepool animal with eight overlapping shells is the: isopod, chiton, boot chiton, sea urchin.
4. Crabs and barnacles belong to the group called: mollusca, arthropods, echinodermata, cnidaria.
5. The Fitzgerald Marine Reserve was established in: 1935, 1955, 1969, 1980.
6. The giant green anemone has been observed to live: 10, 20, 65, 80 years.
7. Acorn barnacles live in the: low tide zone, high tide zone, mid-tide zone, subtidal zone.
8. Waves are produced by the: tides, sun, wind, moon.
9. It takes a rock-boring clam 2, 5, 7, 10 years to bore a four-inch hole in a rock where it will live.
10. The standing cement pillar at the south end of Moss Beach was built in WWII by: the U.S. Army, Navy, National Guard, Coast Guard.

1. sculpin 2. dinoflagellates 3. chiton 4. arthropods 5. 1969 6. 80 years 7. high tide zone 8. wind 9. 10 10. Navy

Friends of Fitzgerald Marine Reserve

Donation Chair, P.O. Box 669, Moss Beach, CA 94038, or through our website: **https://www.fitzgeraldreserve.org/donations**

Contribution Levels:

❑ $25 ❑ $100 ❑ $1000

❑ $50 ❑ $500 ❑ Other _____

❑ I want to double the value of my gift through my employer's matching gift program (please enclose the matching gift forms).

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