Western Society of Naturalists

102\textsuperscript{nd} Meeting Program
Welcome to the 102nd Annual Meeting of the Western Society of Naturalists! WSN’s roots can be traced back to 1910 when a group of biologists, concerned about the lack of scientific meetings on the west coast, formed the Biological Society of the Pacific (call this our larval phase). The BSP was intended to include “any person interested in scientific work of a research nature.” In 1915, the American Society of Naturalists invited the BSP to join as a Pacific chapter under the ASN banner. Although the BSP voted in favor, the merger was eventually rejected by the ASN Executive Committee, who felt that we might not be sufficiently selective in admitting members. Through this process, the BSP formally metamorphosed into the Western Society of Naturalists in 1916.

The first annual meeting of the society that would become WSN featured four scientific presentations and a dinner. Since then, our meetings and our society have grown substantially, but we still proudly welcome everyone who is interested in scientific work of a research nature.

This year, we celebrate our 102nd meeting. The circumstances are unusual, we are in the midst of a global pandemic, and also in a period of increased commitment to our society’s diversity, equity and inclusion of all naturalists. This year’s meeting is virtual - entirely online. We are excited to welcome over 500 participants to this year’s meeting, hundreds of excellent talks, and in addition to our traditional plenary sessions, we will enjoy a new plenary session organized by our Diversity, Equity and Inclusion committee on Friday morning.
**Registration and General Information**

Registration is online through CVENT (as always) and available throughout the conference. After registering, use the same email you used to register to sign onto the online conference platform: Whova [https://whova.com/portal/calpo_202111/](https://whova.com/portal/calpo_202111/)

**WHOVA AND MEETING AGENDA**

This year’s meeting will be hosted on Whova, a web interface that will allow us to integrate Zoom presentations with other virtual events (note you do not need a zoom account to participate). Whova is also where you can find the current meeting agenda! Please note that the Long Program, the Short Program, and the Grid Schedule (back by popular demand) can also be found on the WSN Website, but these documents may not be as current as Whova (i.e., last-minute cancellations, etc).

**SIGN IN HERE:** [https://whova.com/portal/webapp/calpo_202111/sign_in/](https://whova.com/portal/webapp/calpo_202111/sign_in/)

- You should not need a special passcode, but you **MUST use the same email address to sign in that you used during conference registration**.
- If you prefer, there is a phone app available (“Whova”). But this is not required. The web application will suffice.
- Google Chrome is recommended for optimal browser experience
- You will know you are logged in if you see your name in the upper righthand corner

* Although the Whova WSN website displays a lot of the meeting content without needing a login, you will need to be logged in to Whova for full functionality. If you are having trouble finding something (e.g., a poster or a session link), make sure you are logged in using the “SIGN IN” link above.

**EXPLORE AND MAKE YOUR OWN AGENDA**

We recommend that everyone open the Whova web interface, sign in, and explore the agenda before the conference begins. Note that the “AGENDA” link at the left will open a new page on which you can toggle between “full agenda” and “my agenda.” For each of the great events offered this weekend, you can “Add to agenda”, which will compile your personalized list of events, presentations, and coffee breaks to attend. So start building your 2021 WSN agenda now!

**Oral presentations**

On Whova, you will find the meeting agenda, which includes links to plenaries, symposia, and contributed talks. Larger events -- the Meeting Welcome; Student, Presidential and DEI Symposia; the Naturalists of the Year Plenary; and the Presidential Address -- will be hosted as webinars. You will be able to see and hear the speakers / panelists, but you won’t be able to
share your video or unmute your microphone. You will be able to participate with questions via
the Q & A feature on Whova (Chat will be disabled). You also can “raise your hand” in Zoom and
then the host can enable your audio so that you can ask your question verbally.

The contributed talks will be held in concurrent sessions and hosted as Zoom meetings. You will
be able to have your camera on and unmute your microphone to ask questions during the Q & A
breaks. We remind everyone that the WSN Code of Conduct applies to the virtual meeting
space as well as physical meeting spaces. Please note that virtual Zoom rooms have maximum
capacities just like in-person meeting rooms, so please join early if a particular session is of
special interest to you. Also note that while you can move among concurrent sessions and we
will do our best to run on time, it is likely that the concurrent sessions will differ slightly from one
another in timing just like at an in-person meeting. The talk times listed on the program should
be reasonably accurate but will not be exact. Arrive early, when possible.

Roughly 90% of the oral presentations will be available for viewing on YouTube. If you want to
know which talks will and will not be available on YouTube, you can find this information in the
long program (posted on the WSN website).

VIEWING PRESENTATIONS
Join a talk by joining a session (labelled as the session name). During a session, moderators
and participants should use the Q & A box in the session link exclusively. After a session, use
the Q & A box in the subsession (labelled as the talk title) to leave questions for speakers to
answer later that are specific to the talk.

This year when joining a presentation, you will have the option to join through a Zoom window
inside Whova or through Zoom directly. Please mute your audio and turn off your video
whenever you enter a room but feel free to turn them on during any live session Q & A.

- The chat boxes within Zoom and Whova will be turned off to limit distractions. For
  concurrent sessions, use the Whova Q&A box positioned to the right of the session
  window. (see section below on asking questions)

ASKING QUESTIONS
Here we provide information on how to interact during different session types. This may vary
slightly by session, but will help to standardize communication for everyone.

5 minute talks.
Periodic Q & A breaks are scheduled within the 5-minute talk sessions (typically after each set
of five 5-minute talks). You will have two ways to ask questions. First, at any time during the
playback or Q & A session, you may type your question into the Whova Q & A box (remember to
use the Session link itself to find the correct Q & A box). Everyone may “like” the questions that
they prefer, and speakers will have an opportunity to type their answers. Second, during the Q & A session, you may click the “participant” button within Zoom to “raise your hand” and indicate your desire to ask a question verbally. The moderator may call on you to ask your question live. If you think of a question for a speaker after the session ends, click on their specific subsession link to access the presentation-specific Q & A box and type your question there. The author will hopefully answer your question when they can. Alternatively, send them a direct message through Whova!

15 minute talks.
Speakers who have recorded 15 minute talks may have stopped presenting at 12 minutes, leaving 3 minutes for questions. There will be no additional Q & A session at the end of the session. During each 15 minute talk, you may type your question into the Q & A box (remember to use the Session link itself to find the correct Q & A box). Everyone may “like” the questions that they prefer, and speakers will have an opportunity to type their answers. If there is a 3-minute Q & A period, you may click the “participant” button within Zoom to “raise your hand” and indicate your desire to ask a question. The moderator may call on you to ask your question live. If you think of a question for a speaker after the session ends, click on their specific subsession link to access the presentation-specific Q & A box and type your question there. The author will hopefully answer your question when they can. Alternatively, send them a direct message through Whova!

Large plenary addresses and symposia
During large sessions (webinars), you can ask questions via the Q & A text box. You also can “raise your hand” in Zoom and then the host can enable your audio so that you can ask your question verbally.

TIMING OF PRESENTATIONS
- Arrive early for every talk, if possible. Start times of talks may vary by up to 1 minute… and most talks are only 5 minutes in length! So think ahead when bouncing between sessions.
- Some presentations will be available on YouTube after the conference. These talks have “youtube” written after their title on the long program, found on the WSN website.

POSTERS
Posters can be viewed in Whova at any time during the meeting by checking out the “Posters” area. You can leave questions or comments in the chat field of each presenter’s booth. There will also be a dedicated poster session on Saturday afternoon with live Q & A over Zoom.

Poster session live Q & A
On Saturday November 13th, 2021 from 1:30PM-4:30PM there will be a live Q & A for poster presenters that will take place in 4 concurrent Zoom rooms labelled Poster Session 1-4. Each presenter has been assigned a 30 minute slot in one of these three rooms to answer questions along with 2-3 other presenters. Poster presenters - please note what Poster session you are assigned to and at what time you should be present to answer questions. Attendees - attend these sessions to ask any questions to poster presenters.

NETWORKING AND SOCIALIZING
One of the best parts of WSN meetings is the opportunity to meet new people, network, and catch up with friends. We are trying out several avenues to maintain these aspects of the meeting.

Connecting with people within Whova
- Send speakers/exhibitors a message through Whova. These messages will pop up in their private Whova inbox and send them a notification.
- Join in the Q & A for sessions either live or in the chat or connect with others in the same session through the session-specific chat window.
- Create your own virtual meet-up - navigate to the Community tab > Meet-ups and Virtual Meets > Suggest a Meet. Here you can add your own Virtual Meeting URL, name the meet-up and set the date and time information for others to join.
- Add a new discussion topic under the “Community” tab for others to participate in.

Meet new friends and connect with old ones at the Topical Cafe and Off-Topical Cafe!
- We have created virtual meet-up spaces through Wonder - a fun virtual platform (no account required to join!). The Wonder room will be open for the duration of the meeting. Links to this room can be found at most of the breaks, but feel free to join these rooms at any time and meet-up with fellow attendees!
- Chat Room Link: https://tinyurl.com/WSNChatRoom
- To participate: log in and move your little icon toward a location, friends, or attendees you’d like to meet. When you are close together, your circle of people will begin sharing audio and video as if you were all seated around the same table.
  - Link to a 2-min video showing you how to use Wonder.

Mentorship program.
- If you have signed up for the new mentorship program, you should have received further instructions from the program organizers. We are excited about this new initiative to make the WSN meetings more inclusive!

Find Us Online!
We are online at https://www.wsn-online.org. In addition, we maintain a WSN Twitter account (@WSN_Secretariat), Facebook page (http://www.facebook.com/pages/Western-Society-of-Naturalists/263186863792393), and Instagram account (@westernsocietyofnaturalists) where you can find information about the Society and our annual meeting, and connect with your colleagues. Our Student Committee also maintains separate accounts on Twitter (@WSN_Students) and Instagram (@wsn_students). If you have an opportunity that would be appropriate for distribution via the WSN social media accounts (fellowships, small grants, student opportunities, etc.), please reach out to the Secretariat or Student Committee through these platforms.

WSN IS ON INSTAGRAM…

… and we want to feature you! Want your work, field site, study organism, or recent publication to be featured on WSN's Instagram feed? Send a photo and a short blurb to @wsn_students or @westernsocietyofnaturalists Material will be accepted at any time on a rolling basis. Tweet your merchandise photos using the hashtag #2021WSNmerch

2021 Student Committee
Ric de Santiago (San Diego State University/UC Davis)
Montana McLeod (Oregon State University)
Brandon Quintana (CSU Fullerton)
Jessica Weidenfeld (SDSU)
Margaret (Maggie) Slein (Reed College)
Ben Walker (UC Santa Cruz)
Ilana Ayelen Rivera Larrea (Ensenada Center for Scientific Research and Higher Education (CICESE)

Thanks to Student Travel Fund Donors
We are grateful to all of you who made donations to the Student Travel Fund when you registered; those funds are greatly appreciated by our many student members. We look forward to sending students next year, thank you!

Merchandise
Order online this year! https://www.wsn-online.org/merchandise-2021/
Note: This year, merchandise was made available to our membership through redbubble.com. The site will only be open until the conference, so please get your merchandise before then!

Auction: Proceeds from the silent auction will support the Student Travel Fund for next year! We have two different auctions this year:

Silent Auction
The silent auction will take place virtually this year. The silent auction will run from Thursday November 5th and will close Saturday November 7th at 8:00pm, just before the Presidential Address. Winners will be announced at the end of the special live auction ceremony! We will be accepting PayPal and checks.

Link to auction platform: https://www.32auctions.com/WSNSilentAuction2021
To bid on an item you must register at:  https://www.32auctions.com/users/new
When you register, please include both your email AND your phone number so we can contact you about payments and shipping. If you wish to remain an anonymous bidder, please create an anonymous username (your full name will not be displayed).

If you won an auction item and have not been contacted, please contact Ilana Ayelen Rivera Larrea, at ilana@cicese.edu.mx

Live Auction Event
Join Ben Ruttenberg and Kerry Nickols for a live auction extravaganza! We will be auctioning off some art pieces, excursions and special books. The live auction is Saturday, November 13th from 7-8pm.

Event link:  Password: WSNAuction

Trivia Night!
Join us Friday November 12th from 7-9pm for a WSN trivia extravaganza! Create a team with your lab mates, your collaborators, friends or even strangers! Anyone can join the event at 6pm, no sign up necessary.

Trivia link:  www.crowd.live/2021TRIVIA  (No App required)

Sign-up your team name:  www.tinyurl.com/WSNTriviaSignUp  Sign up to secure a team name for trivia night! Team names must be created before 3pm Friday, November 12th to reserve a team name for trivia night. Individuals not part of a team are encouraged to sign up!

WSN 2022: JOIN THE STUDENT COMMITTEE
Every year, we look for new members of the WSN student community who would like to join the WSN Student Committee and help our meetings continue to thrive. To be eligible for consideration you must be a current student, and be able to serve for one (for undergrads) or two (graduate students) consecutive years. Applications usually open in August prior to the meeting; follow us on Twitter (@WSN_Students) and Instagram (@wsn_students) for updates!

Diversity, Equity, and Inclusion
WSN is committed to creating and maintaining an environment in which all attendees can participate without harassment, discrimination, or violence of any type. In support of this goal, the society has established a Diversity, Equity, and Inclusion Committee, whose members include Corey Garza (Chair), Cheryl Barnes, Alexandra Davis, Mike Gil, and Crystal Ng.

Western Society of Naturalists Meeting Code of Conduct
The Western Society of Naturalists (WSN) annual meeting is intended to foster the exchange of scientific ideas, provide participants with an opportunity to present research findings, establish and renew collaborations, facilitate recruitment of students and staff to laboratories and institutions, and to learn, teach, and network with an international community of scientists. WSN
is committed to creating an environment in which all attendees can participate without harassment, discrimination, or violence of any type. This Code of Conduct applies to all events at the WSN annual meeting, including all meeting-related activities of participants. **All meeting participants must be treated with respect, regardless of race, gender, sexual orientation, gender identity/expression, ethnicity, ability, religion, language, professional status, institution or age. All meeting participants including, but not limited to, members, volunteers, attendees, vendors, exhibitors, contractors, and guests are expected to abide by this WSN Meeting Code of Conduct.**

**Expected behavior includes (but is not limited to):**

- Treating all participants and meeting facilities with respect and consideration.
- Communicating openly with respect for others, critiquing ideas rather than individuals.
- Avoiding personal attacks directed toward others.
- Respecting the rules and policies of the meeting venue, hotels, WSN contracted facility, or any other venue.
- Abiding by the principles of academic integrity and ethical professional conduct.

Harassment or discrimination by or of any meeting participant or of any type will not be tolerated.

**Unacceptable behavior includes (but is not limited to):**

- Behavior that implies or indicates that someone does not belong at the WSN meeting based on any personal characteristic or identity.
- Any unwanted attention, sexual advances, and comments about appearance.
- Verbal harassment, including comments, epithets, slurs, threats, and negative stereotyping that are offensive, hostile, disrespectful, or unwelcome.
- Non-verbal harassment, including actions or distribution, display, or discussion of any written or graphic material toward an individual or group that ridicules, denigrates, insults, belittles, or shows hostility, aversion, or disrespect.
- Bullying, intimidation, stalking, shaming, and assault.
- Retaliation for reporting harassment.
- Reporting an incident in bad faith.

**Consequences:** The WSN Secretariat reserves the right to enforce this Code of Conduct in any manner deemed appropriate. Anyone violating the Code of Conduct will first be asked to cease these behaviors. Failure to comply with requests can result in escalating consequences which may include, but are not limited to, (a) expulsion from the meeting, (b) prohibition from future meetings or (c) revocation of WSN membership.

**Reporting:** If you are the subject of unacceptable behavior or have witnessed any such behavior, please immediately notify a member of the WSN Secretariat. Notification can be done by contacting a member of the WSN Secretariat on-site or via e-mail to secretariat@wsn-online.org.
SCHEDULE AT A GLANCE: MAIN EVENTS

15-minute presentations include Q & A -- there will be no other time provided for Q & A
5-minute presentations exclude Q & A -- there will be time for Q & A after every ~5 talks

THURSDAY, NOVEMBER 11, 2021

1800-2015 STUDENT WORKSHOP
Co-chairs: Maggie Slein & Jessica Weidenfeld
“Increasing the Impact of your Science”

FRIDAY, NOVEMBER 12, 2021

0810-0820 Meeting Welcome. Steve Lonhart

0820-0950 STUDENT SYMPOSIUM
Chair: Brandon Quintana
“Underrepresented voices in the environmental justice movement”

0950-1020 BREAK

1020-1100 NATURALISTS OF THE YEAR AWARD
Presented by Jenn Caselle

1100-1230 Diversity, Equity, and Inclusion Symposium
Chair: Corey Garza
“Cutting the strings: beyond parachute science”

1230-1430 BREAK / MENTORSHIP MIXER
PRIMED Marine Disease Group Meeting (1330-1430) (info/signup here)

1430-1530 CONTRIBUTED PAPERS (5-minutes)

1530-1600 BREAK

1600-1700 CONTRIBUTED PAPERS (5-minutes)

1700-1745 AFFINITY GROUP MIXER*: BIPOC (Black, Indigenous, People of Color)
1745-1830 AFFINITY GROUP MIXER*: People with Disabilities
* Affinity groups provide safe spaces for people with historically marginalized identities to gather, build community, and bolster a sense of belonging in WSN. You must identify as a member of any affinity group that you intend to join. WSN attendees are encouraged to participate in as many affinity groups as they identify with. Please also feel free to add affinity group meetings not already offered during any break.

1830-1900 BREAK
1900-2100 TRIVIA (ATTITUDE ADJUSTMENT HOUR)

SATURDAY, NOVEMBER 13, 2021

0800-1000 PRESIDENTIAL SYMPOSIUM
   Chair: Steve Lonhart
   “Several paths to public service”

1000-1030 BREAK

1030-1200 CONTRIBUTED PAPERS (5-minutes)

1200-1330 LUNCH

1200-1245 AFFINITY GROUP MIXER*: LGBTQIA2+ (Lesbian, Gay, Bisexual, Transgender, Queer/Questioning, Intersex, Asexual, Two-spirit +)
1245-1330 AFFINITY GROUP MIXER*: First Generation College Students (past/present)
   * Affinity groups provide safe spaces for people with historically marginalized identities to gather, build community, and bolster a sense of belonging in WSN. You must identify as a member of any affinity group that you intend to join. WSN attendees are encouraged to participate in as many affinity groups as they identify with. Please also feel free to add affinity group meetings not already offered during any break.

1330-1630 POSTER SESSION

1630-1700 BREAK

1700-1800 ANNUAL BUSINESS MEETING. All members are welcome - come help shape the future of our society

1800-1900 BREAK

1900-2000 WSN AUCTION

2010-2100 PRESIDENTIAL ADDRESS: Steve Lonhart
   Presidential Trivia:  https://www.crowd.live/PREZTEST (No App required)

SUNDAY, NOVEMBER 14, 2021

0900-1030 CONTRIBUTED PAPERS (15-minutes)

1030-1100 BREAK

1100-1230 CONTRIBUTED PAPERS (15-minutes)

1230-1240 MEETING ADJOURNMENT
Contributed Talks

Session 1: Intertidal Ecology I

* indicates presenting author, † indicates eligibility for Best Student Paper Award

ROCKY INTERTIDAL MONITORING OF RED ABALONE IN CALIFORNIA’S NORTH CENTRAL COAST MARINE PROTECTED AREAS (YOUTUBE)
Douglas, M.A.1*; Ammann, K.N.; Cortez, M.L.; George, M.K.; Necarsulmer, A.M.; Raimondi, P.T.
1- UC Santa Cruz 2- University of California Santa Cruz

The 1999 Marine Life Protection Act (MLPA) mandates the establishment of a network of Marine Protected Areas (MPAs) along the California coast. In May 2010, the North Central Coast Study Region (NCCSR), the second of five study regions, was implemented. It includes 25 MPAs from Point Arena to Pigeon Point. Our research group at UC Santa Cruz supplemented our existing long-term monitoring sites to increase spatial coverage within the NCCSR region. Key elements of this monitoring program include assessment of biodiversity, community structure, and species of special interest. Here, we focus on our monitoring of an ecologically and economically important species of interest, red abalone (*Haliotis rufescens*). In addition to being useful for capturing and understanding broad scale temporal and spatial changes, this long-term monitoring also informs policy and management decisions. The red abalone recreational fishery was closed in 2017 due to a significant decline in stocks resulting from multiple environmental stressors. With the subsequent decline in kelp beds and lack of population recovery the Fish and Game commission extended the closure to 2026. Our research group most recently monitored this critical species during summer 2021. Here, we report our findings along with a discussion of possible factors and implications.

RECENT BLACK ABALONE (*Haliotis cracherodii*) RECRUITMENT PROVIDES HOPE FOR RECOVERY (YOUTUBE)
Bell, C.A.1*; Miner, C.M.; Parsons-Field, A.; Whitaker, S.; Fletcher, N.C.; Gaddam, R.N.; Raimondi, P.T.
1- University of California, Santa Cruz 2- University of California, Santa Barbara 3- Channel Islands National Park

Black abalone (*Haliotis cracherodii*) were abundant on offshore islands and along the mainland coast of California, USA and Baja California, MEX until the mid-1980s when populations experienced massive declines due to a fatal wasting disease called “withering syndrome”.Declines were so severe throughout most of the species’ range that black abalone were listed as “critically endangered” under the USA Endangered Species Act in 2009. Researchers from the Multi-Agency Rocky Intertidal Network (MARINe) have been monitoring black abalone at sites throughout their range for the past 20-40 years, and although a handful of areas on the Channel Islands have shown signs of population recovery, virtually no recruitment had been observed along the southern California mainland. Over the last few years, we have documented the first signs of successful recruitment and population growth within these remnant populations. While densities are still much lower than they were historically, these recent observations provide hope for future recovery.

CRABS IN SPACE: INVESTIGATING SPATIAL AND TEMPORAL DYNAMICS OF SALT MARSH CRAB COMMUNITIES (YOUTUBE)
Dunn, R.P.1*; Gutierrez, N.
1- University of South Carolina 2- Georgia College & State University

Small-bodied crabs are a key set of taxa inhabiting salt marsh ecosystems because of their roles as herbivores and as prey for higher trophic levels, as well as their impacts on biogeochemical cycling through bioturbation. We investigated differences in abundance and activity of crabs across salt marsh elevation gradients and at different temporal scales. The North Inlet-Winyah Bay National Estuarine Research Reserve, in South Carolina, USA has permanent monitoring transects across the marsh platform from forest edge to creek bank. We conducted monthly pitfall trapping and burrow counts at 50 plots along these transects to monitor crab activity within the high, mid and low marsh zones. To understand temporal variability in crab abundance, we also sampled crabs and burrows at increasingly short time scales from monthly to daily. Marsh crab catch-per-unit-effort (CPUE) was highest in the spring and summer due to reduced crab activity during cool
months, while variability in CPUE was similar across temporal scales, suggesting that monthly sampling is sufficient for monitoring marsh crab populations. The lower marsh zone exhibited higher burrow densities and lower CPUE compared to the mid and high marsh zones at all sampling intervals. We hypothesize that this is because crabs caught in the mid or high marsh are foraging away from burrows located in softer sediments in the low marsh and because the behavior of mud crabs inhabiting low marsh zones may reduce their susceptibility to collection using pitfall traps compared to fiddler crabs found at higher elevations.

**SEA WARS: THE RISE OF INTERTIDAL SEA URCHINS**

Haupt, AJ; Dawson, L; Del Toro, A; Haberman, I; Micheli, F; Pureco, D; Rooney, K; Siegel, P; Vidusic, E

1- Department of Marine Science, CSU Monterey Bay 2- Moss Landing Marine Lab 3- Hopkins Marine Station, Stanford University

Herbivores play an important role structuring ecosystems by consuming foundation species. Recently kelp forest ecosystems have seen a drastic increase in sea urchin populations and loss of kelp habitat. Many studies have documented the rise of sea urchins and development of sea urchin barrens - where urchins likely have very low reproductive output due to low gonad health - in the subtidal. Less attention has been paid to increases in urchins in intertidal habitats where there may be higher food quality than in subtidal barrens. Past work found very low densities of purple sea urchins in the intertidal. Classes at CSU Monterey Bay have continued to monitor densities of urchins at four sites from 2016 - 2020 and during summer 2021 we revisited six sites that were surveyed in 2002 to assess urchin densities and sizes. Urchin densities have increased dramatically in the intertidal in the Monterey Peninsula. The intertidal has the potential to serve as a reproductive refuge when subtidal urchins in barrens have low gonad quantity. Understanding urchin dynamics in the intertidal will be important for forecasting changes in subtidal kelp forests.

**UNTANGLING THE DIVERSITY OF RIBBON WORMS IN THE BODEGA BAY REGION**

Sanford, Eric; Ellison, Christina I.; Frey, Madeline R.; Maslakova, Svetlana A.

1- Bodega Marine Laboratory, University of California Davis 2- Oregon Institute of Marine Biology, University of Oregon

Zoologists have studied intertidal communities in California since the 1800s, contributing to a general perception that the diversity of marine invertebrates on our shores has been well described. In reality, surprisingly little is known about the taxonomy and natural history of many coastal invertebrates. In this study, we explored the diversity of ribbon worms (Phylum Nemertea) in the Bodega Bay region of northern California. Although nemerteans are common and ecologically important mesopredators in coastal ecosystems, they have received relatively little attention in California since the foundational taxonomic work by Wesley Coe in the early 1900s. During the summers of 2019 and 2020, we collected nemertean specimens from a variety of habitats in the Bodega Bay region, including rocky intertidal shores, sandy beaches, and mudflats. Based on morphological assessment and analyses of sequence data (COI and 16S genes), our surveys identified 34 nemertean species. Eleven of these (32%) represent species new to science. Nine (26%) have been found previously on the Pacific Coast of North America but are not yet described. Only 12 (35%) can be assigned unambiguously to described species, whereas species identity of two others is uncertain. Our findings highlight how much remains to be learned about nemerteans in the northeastern Pacific. More broadly, we emphasize that there is an urgent need to support the work of field biologists, taxonomists, and museums to document the diversity and distribution of coastal species during an era of rapid global change.

**ECOSYSTEM RECOVERY AT A SNAIL’S PACE: CAN COMPENSATORY PREDATION CONFER RESILIENCE AFTER SEA STAR WASTING?**

† Bachhuber, Silke M.†; Gravem, Sarah; Menge, Bruce A.

Oregon State University

Whelks in the genus *Nucella* are voracious and important predators in rocky intertidal habitats along the Northeast Pacific coast. Along with several other species, they became de facto top predators when populations of the keystone predator *Pisaster ochraceus* were decimated by Sea Star Wasting Syndrome in 2013-14. Profound effects of *Nucella* predation on mussel and barnacle populations have been documented in areas
where they are highly abundant, but variation in predator effects on a broader spatial scale is not well understood. We ask whether two morphologically similar species, *Nucella ostrina* and *N. emarginata* (hereafter referred to as *Nucella*), can compensate for reduced mussel predation by *Pisaster* post-SSW. We conducted a caging experiment at 13 intertidal sites in Oregon and California. Treatments either excluded all mobile organisms from the experimental plot or included *Nucella* in cages at site-specific densities. Study sites span a gradient of environmental conditions and predator densities. Preliminary results indicate a “goldilocks” condition is required for *Nucella* to prevent mussel takeover in the absence of *Pisaster*. Recruitment must be high enough for predators to have discernible control over prey populations, yet not so high as to overwhelm predation effects. Understanding the spatial variability of food web dynamics, even in intensively studied systems, is a key component of improving predictive capacity in the face of marine disease outbreaks, trophic downgrading, and climate change.

**THE EFFECTS OF OCEAN ACIDIFICATION AND WARMING ON THE BEHAVIOR AND PHYSIOLOGY OF AN INTRITIDAL GRAZER AND KEY SEA STAR PREDATOR** (YOUTUBE)

† Bacus, S.B.1*; Kelley, A.L.; Mincks, S.H; Gaylord, B.P.

1- University of Alaska Fairbanks 2- University of California Davis

Considering the ocean is expected to both acidify and warm concurrently, multiple-stressor manipulative experimentation is an emergent area of study that aims to examine the individual and interactive effects of these factors on marine organisms. Here, we examined both the individual and interactive effects of an acidifying and warming ocean on the behavior and physiology of the intertidal grazer, *Lottia scutum*, and a key sea star predator, *Evasterias troschelii*. Throughout our study we conducted a thermal tolerance assay, closed-system respirometry, a cortisol enzyme-linked immunosorbent assay (ELISA), and a behavioral assay. We found that ocean warming (OW) negatively affected the critical thermal maxima (CTmax) of *Lottia scutum* and positively affected cortisol expression. Additionally, there was an effect of ocean acidification (OA) on the mass-specific metabolic rate of *Lottia scutum*. While we hypothesized that OA and OW would affect the anti-predator behavior of *Lottia scutum*, we concluded that pH and temperature had no significant effect on the anti-predator behavior of *Lottia* when exposed to *Evasterias troschelii*. The results from this study highlight the need for future studies to integrate multidisciplinary experimental designs that span multiple levels of biological organization to make ecologically relevant predictions for how marine organisms will respond to ocean change.

**A META-ANALYSIS OF THE LETHAL AND SUBLETHAL EFFECTS OF OCEAN WARMING, ACIDIFICATION AND THEIR COMBINATION ON MARINE ECTOTHERMS** (YOUTUBE)

† Beaty, F.L.1*; Calvo, L.; Lyons,D.L.; Harley,C.D.G.

1- University of British Columbia 2- Department of Fisheries and Oceans

Climate change is causing oceanographic properties to rapidly shift and affect the fitness of many marine species. These effects are highly variable due to life-history traits that differ across taxonomic groups and stressor interactions. Here we present a comprehensive meta-analysis that reviews the individual and interactive effects of ocean warming and acidification on marine ectotherms, with specific attention toward the relative impacts of these stressors on sublethal and lethal performance metrics. Our database comprises 98 papers (306 experiments) published between 2012-19 that align with our inclusion criteria. We calculated mean effect sizes for response variable categories across taxonomic groups. We also conducted a paired analysis of the overall sublethal and lethal mean effect sizes and categorized interactive effects into synergistic, antagonistic and null categories. Our results indicate that warming and acidification negatively impact calcification and growth when acting independently, and temperature negatively impacts survival. When comparing across lethal and sublethal responses, warming caused significantly greater lethal effects, whereas there was no difference across lethal and sublethal performance in acidified or factorial treatments. Overall, this synthesis indicates that in a warming world, marine ectotherms may die before their sublethal responses compromise their fitness, but in a multiple-stressor world it is likely that both sublethal and lethal performance metrics will matter in determining a species’ adaptive capacity and persistence.
Session 2: Community Ecology I

* indicates presenting author, † indicates eligibility for Best Student Paper Award

Towards a more holistic understanding of the pathogenic microbiome of eelgrass wasting disease
Beatty, Deanna1*; Aoki, Lillian; Rappazzo, Brendan; Domke, Lia; Eckert, Ginny; Graham, Olivia; Harper, Leah; Hawthorne, Timothy; Hessing-Lewis, Margot; Hovel, Kevin; Monteith, Zachary; Mueller, Ryan; Olson, Angeleen; Prentice, Carolyn; Tomas, Fiona; Bo Yang; Emmett Duffy; C. Drew Harvell; Carla Gomes; John J. Stachowicz

1- University of California, Davis 2- University of Oregon 3- Cornell University 4- University of Alaska 5- Smithsonian Institution 6- University of Central Florida 7- Hakai Institute 8- San Diego State University 9- Oregon State University 10- San Jose State University

Marine host-associated microbiomes are vital to ecosystem function but are threatened by anthropogenic stressors and disease. Due to their rapid turnover, microbes may act as early warning indicators of host stress or disease. Host-associated microbes of the widely distributed eelgrass, Zostera marina, fix nitrogen, remove toxins, and produce antifouling compounds. Thus, Zostera-associated microbes may inhibit colonization and proliferation of harmful microorganisms or serve as an early sign of disease. We investigate how Z. marina phyllosphere microbiomes respond to eelgrass wasting disease (EWD), caused by protist pathogen Labyrinthula zosterae across 32 meadows and 23º latitude. Disease prevalence and severity were quantified by an artificial intelligence system, Eelgrass Lesion Image Segmentation Application (ELISA), and microbial predictors of disease were identified by random forest analysis. Despite small effect sizes of disease on microbiome structure across our latitudinal range, we identify bacterial exact sequence variants and families on asymptomatic tissue that are predictive of wasting disease prevalence within meadows. Further, we found Cellvibrionaceae, known degraders of plant cellulose, enriched in EWD lesions. Members of Cellvibrionaceae and other enriched bacterial groups may play important roles in EWD dynamics, by degrading host tissues or promoting pathogen L. zosterae. Thus, by moving toward a more holistic understanding of the pathogenic microbiome, we may be able to predict outcomes of disease.

DISTURBANCE STRUCTURES KELP CANOPY AND UNDERSTORY PRODUCTIVITY ALONG AN ENVIRONMENTAL GRADIENT: EVIDENCE FROM A 10-YEAR EXPERIMENT (YOUTUBE)

Castorani, M.C.N.1*; Harrer, S.L.; Miller, R.J.; Reed, D.C.

1- University of Virginia 2- University of California, Santa Barbara

Ecological disturbances often disproportionately impact different vegetation layers in vertically-stratified ecosystems, such as kelp forests and coastal wetlands, shaping community structure and ecosystem function. However, disturbance-driven changes may be mediated by environmental conditions that affect habitat quality and species interactions. In a decade-long field experiment at the Santa Barbara Coastal Long Term Ecological Research project, we tested how kelp forest net primary productivity (NPP) responds to repeated canopy loss along a gradient in grazing and substrate suitability. We discovered that benthic habitat quality (sea urchin density and sand cover) can mediate the effects of intensified disturbance on canopy and understory NPP. Experimental pulse and press disturbances suppressed total macroalgal NPP, but effects were strongest in high-quality habitats that supported dense canopies of giant kelp (Macrocystis pyrifera) that were removed by disturbance. A diversity of understory macroalgae partly compensated for canopy NPP losses and this effect magnified with increasing habitat quality. Disturbance-driven increases in understory NPP were still rising after 7-10 years of disturbance, demonstrating the value of long-term experimentation for understanding ecosystem responses to rapidly changing disturbance regimes.

Effects of Marine Protected Areas on Catalina Island Algal and Invertebrate Communities (YOUTUBE)

Dillon Dolinar*; Selena McMillan

Reef Check California

Marine protected areas (MPAs) are a widely used marine management tool that have been shown to conserve
biodiversity, ecosystem function and ecosystem services. Additionally, it has been shown that MPAs can decrease invasive success of non-native species. The invasive alga, Sargassum horneri, was introduced to Southern California in 2003 and has since replaced the foundational native giant kelp, Macrocystis pyrifera, as the dominant alga on many reefs, specifically on Santa Catalina Island, CA. Using survey data collected by Reef Check volunteers, we examined how the densities of S. horneri and M. pyrifera vary by year both inside and outside of MPAs at eleven sites at Catalina Island. Additionally, we examined impacts that MPAs are having on invertebrate community structure. We observed that from 2016-2019, M. pyrifera was more abundant at sites that were located within MPAs, while densities of S. horneri were higher at sites located outside of MPAs. In addition, while we did not observe an MPA effect on invertebrate species richness at our sites, we did observe differences in invertebrate community structure as a result of MPA status. Our results provide further evidence that MPAs can provide resistance to invasive alga, and increase densities of native foundation species. Additionally, the findings from this study suggest that MPAs on Catalina Island are capable of sustaining the historical invertebrate community structure.

Empirical evidence that a keystone species stabilizes a Northeast Pacific nearshore ecosystem in the face of climate change (YOUTUBE)

Shawn Larson*; Alex Tanz; Jenna Rolf; Zachery Randell

Seattle Aquarium

The sea otter urchin and kelp forest trophic cascade is a well-documented nearshore phenomenon. When sea otters are present, they control urchin populations thus releasing kelp forests from over grazing allowing kelp to flourish. Recent studies have pointed to the possibility that there may be an additional benefit of keystone species such as sea otters to benthic nearshore communities in the face of climate change. The Seattle Aquarium has been annually monitoring temperate benthic reef systems in and around Neah Bay since 2005. The aquarium conducts SCUBA based surveys to track changes in fish, invertebrate and algae communities over time. The aquarium monitors five survey sites, one associated with a small group of sea otters and four without sea otters. Starting in 2014 there was a widespread warm water event in the Northeast Pacific termed “the blob” that was thought to be a catalyst for the disease event, sea star wasting, that eliminated most sea stars. Here we present data on changes in the benthic communities in these survey sites that show ecosystem changes before and after the 2014 events. Our data documents shifts in the benthic community after 2014 from complex systems with sea stars, sponges, various invertebrates and algae to urchin barrens. This is in comparison to the survey site associated with sea otters in which we document little change in the benthic community. This is the first known empirical evidence of a keystone species stabilizing nearshore ecosystems in the face of warm water and disease events caused by climate change in the northeast Pacific.

The very hungry urchin: feedbacks between kelp forest change and animal behavior and physiology (YOUTUBE)


1- University of British Columbia, Hakai Institute 2- Hakai Institute 3- University of Waterloo 4- Hakai Institute, Oregon State University 5- Florida State University 6- University of British Columbia

Kelp forests are productive and diverse ecosystems that provide important services to humans. In recent decades, warming temperatures, extreme climatic events, overgrazing by destructive grazers, and predator declines have caused reductions in kelp cover and shifts in kelp distribution. We conducted experiments in the inner passage and on the central coast of British Columbia to examine how invertebrate grazers respond to and influences these kelp forest changes. Specifically, we conducted lab experiments to examine the effects of habitat type (kelp vs. barren) and climate warming on red urchin metabolism, grazing, and activity rates, and field experiments to examine invertebrate grazing rates across a gradient in kelp cover from kelp to barren. In lab experiments, we found that red sea urchin grazers collected from kelp forests exhibited higher respiration, feeding, and activity rates, and a greater increase in respiration rates in response to elevated temperatures relative to individuals collected from barrens. In field experiments, we found grazing in all habitats, which increased incrementally from giant kelp-dominated to bull-kelp dominated kelp forests, to kelp forests transitioning to barrens, to barren habitats. Grazing rates increased with urchin density, but
were limited by fine-scale habitat features and currents. These results suggest that kelp cover, temperature, and natural stressors strongly influence the physiology and behavior of key grazers, also altering their effects on kelp forest structure and persistence in a changing world.

**ADAPTATION OF SYMBIONTS TO INCREASED TEMPERATURE MAY NOT RESULT IN INCREASED BENEFITS TO HOSTS**

*YOUTUBE*

*terHorst, C.P.*<sup>1</sup>; *Coffroth, M.A.*

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1- *California State University, Northridge* 2- *University at Buffalo*

Species may respond to climate change through evolutionary adaptation. For species with strong symbiotic relationships, such as many coral reef species, evolution of symbionts in response to environmental changes may confer adaptation to the holobiont. To assess the potential for such adaptation, we examined the temperature tolerance of genotypes of *Breviolum antillogorgium*, isolated from the tissues of octocorals in the genus *Antillogorgia* at different temperatures. We found broad temperature tolerance, with all genotypes showing positive growth at 26, 30, and 32 degrees C. However, genotypes differed in the magnitude of the response of growth rate and carrying capacity to increasing temperature, suggesting that natural selection should favor different genotypes at different temperatures. The historical temperature at which genotypes were isolated was not a good predictor of temperature response. We found increasing photosynthetic rates and decreasing respiration rates with increasing temperature, but found no significant differences in the physiological response of genotypes to temperature. Despite adaptation to increased temperature in these algal symbionts in culture, the photosynthetic benefits they provide to hosts may not have the same adaptive response. Selection experiments on symbionts outside of the host may not yield the evolutionary rescue necessary to adapt to climate change, but rather may require selection experiments on the holobiont.

**URCHIN AND FISH PREDATION SUPPRESSES OCTOCORAL RECRUITMENT IN THE CARIBBEAN**

*YOUTUBE*

*Wells, C.D.*<sup>1</sup>; *Benz, J.R.*; *Tonra, K.J.*; *Anderson, E.R.*; *Lasker, H.R.*

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1- *University at Buffalo* 2- *Oregon State University*

While Caribbean scleractinian coral cover has been in decline since scientists have documented coral populations, octocoral abundances have increased. A major influencer of successful recruitment in corals is grazing by both fishes and urchins, both of which have had significant declines in the past 50 years. In order to quantify the effect of fish grazing on field recruitment of octocoral, we deployed pre-conditioned tiles within or outside cages on an octocoral-dominated reef on the southern side of St. John, US Virgin Islands for six weeks. Subsequently, tiles were brought into lab and field-collected octocoral larvae were allowed to settle on these tiles. Settlement was mapped and then tiles were redeployed onto the reef back to their original caging treatment. One *Diadema antillarum* was added to half of the caged tiles. Settlement of new polyps and survival of all polyps was evaluated among treatments, quantifying the effects of urchin and fish grazing on octocoral recruitment for three weeks. Recruitment was significantly higher within cages in the first experiment although there were no differences in recruitment in the second experiment. These differences may indicate that monthly spawning and recruitment events are differentially affected by grazing. Octocoral polyps were significantly more likely to die if they were on tiles without cages or caged with an urchin than if caged without an urchin (65% and 32% more likely, respectively) indicating that grazing by urchins and fishes can have a significant impact on newly-settled octocoral survival.

**USING ARTIFICIAL INTELLIGENCE TO QUANTIFY MOSQUITO DITCHING IN U.S. ATLANTIC COAST SALTMARSHES AT MULTIPLE SCALES**

*YOUTUBE*

† *Aerni, K.E.*<sup>1</sup>; *Bell, T.*; *Kimbro, D.L.*

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1- *Northeastern University* 2- *Woods Hole Oceanographic Institution*

Disturbance is a critical force shaping natural ecosystems whose effects vary along a continuous gradient of intensity and with the organism and spatial scale examined. However, landscape level disturbances can be prohibitively difficult to manually quantify past the limited categorization of high v. low intensity. This subjective delineation removes our ability to detect non-linear responses and thresholds. One such anthropogenic disturbance is mosquito ditching in salt marshes, which has historically been restricted to
presence/absence or low/high categorical studies. We propose that these subjective classifications might be behind uncertainties and conflicting results that have arisen from these studies, and have addressed this knowledge gap by objectively quantifying mosquito ditching in salt marshes. Here, we used a convolutional neural network (CNN) to detect mosquito ditches from satellite imagery for over 300 salt marshes along the U.S. Atlantic Coast. For each marsh, we were able to generate overall metrics of ditching intensity including the total area of mosquito ditches relative to the total marsh area. By quantifying the full gradient in mosquito ditching intensity and spatial variation along the U.S. Atlantic Coast, we can now look for non-linearities and thresholds in ecological responses such as salt marsh bird diversity and make informative cross-site and cross-scale comparisons.

INTERACTIONS AFFECTING COMMUNITY STRUCTURE OF FISHES AND MACROINVERTEBRATES ON HAWAIIAN CORAL REEFS (YOUTUBE)
† Brush, E.G.*; Hixon, M.A.

University of Hawai‘i at Mānoa

As coral reefs face a suite of stressors that threaten to reduce biodiversity and alter ecosystem function, understanding the factors that affect community structure is critical. The south shore of O‘ahu, Hawai‘i, is characterized by reefs dominated by pocilloporid corals, including antler coral (Pocillopora grandis), the large and branching morphology of which attracts many species. The Arc-eye Hawkfish (Paracirrhites arcuratus), a mesopredator, and the Blue-eye Damselfish (Plectroglyphidodon johnstonianus), an interference competitor, are common residents. On six 35-65cm diameter antler corals, I conducted a press removal of both fish species, leaving six other colonies as unmanipulated controls, to determine the combined effects of these strong interactors on resident communities. I removed all non-focal fish from each coral, and then monitored colonization for six months. In the absence of Arc-eye Hawkfish and Blue-eye Damselfish, there was a resulting increase in resident fish abundance and species richness, as well as macroinvertebrate abundance. There was also evidence of increased recruitment of trapeziid guard crabs, which aid the host coral by defending against invertebrate corallivores. Such changes to community structure could affect the host colony, as greater resident fish biomass has been shown to increase coral growth through fertilizing excreta. Understanding the combined direct and indirect effects of predation and competition on community structure may provide insight on future changes to coral reef biodiversity and ecosystem function.

CORALLINE ALGAE ARE NUTRITIOUS! (YOUTUBE)
Haberman, I.E.†*; Shimomura, M; Forster, I; Martone, P.T.

1- Moss Landing Marine Laboratories 2- Department of Fisheries and Oceans Canada 3- University of British Columbia

A long held paradigm in marine herbivore ecology is that coralline algae are less nutritious than other macroalgae, due to their calcified thalli. However, we assert that the per-weight basis (i.e kcal / dry mass) upon which this relies is not ecologically relevant, as herbivores “measure” food intake by the mouthful, not by mass. Thus, a per-volume measurement of nutritional content (i.e. kcal / mL) may be more appropriate. In this study, we measured the caloric content of 6 coralline species and 5 non-calcified species of macroalgae, including 4 highly palatable kelps, to determine correlations between nutritional content and calcification. We found significant differences in caloric content across calcified and non-calcified species based on dry-weight, consistent with the established paradigm, but on a per-volume basis, caloric differences were negligible. In any given volume (mouthful), coralline algae are primarily calcium carbonate, while fleshy algae are mostly water, but both have similar amounts of algal tissue, indicating that differences in nutritional content on a per-weight basis may be unequally skewed by non-algal tissue material composition. Our results show that coralline algae can be just as nutritious (per volume) as fleshy seaweeds, including kelps. Thus, contrary to the old paradigm, we conclude that coralline algae are not significantly less nutritious than non-calcified species on a more ecologically relevant per-volume basis, suggesting that herbivore preference for fleshy seaweeds over coralline algae in the field cannot be explained by nutrition.
Session 3: Special Session: California’s Marine Protected Areas Program: Safeguarding California’s Marine Resources

* indicates presenting author, † indicates eligibility for Best Student Paper Award

ASSESSING FISH SPILLOVER USING 14 YEARS OF TAG-RECAPTURE DATA ACROSS FOUR CENTRAL CALIFORNIA MARINE PROTECTED AREAS (YOUTUBE)
Brooks, R.O.*; Ziegler, S.L.; Hamilton, S.L.; Starr, R.M.

Moss Landing Marine Laboratories, San Jose State University

Marine Protected Areas (MPAs) are conservation tools often designed with two conflicting purposes in mind: (1) to protect marine organisms from fishing, and (2) to benefit fisheries via spillover of larvae, juveniles, and adult fishes beyond reserve boundaries. To date, however, few studies have successfully quantified direct spillover of adult fishes from MPAs to areas open to fishing. We used tag-recapture data generated by the California Collaborative Fisheries Research Program (CCFRP) to quantify spillover of adult nearshore fishes from MPAs. Over 14 years, nearly 44,000 fishes were tagged from 4 MPAs along the central California coast and 310 fishes were recaptured both inside and outside MPAs (0.7% recapture rate). Overall, 18% of adult fishes initially tagged inside a MPA were recaptured in areas open to fishing. These spillover events primarily consisted of Black Rockfish (*Sebastes melanops*), Copper Rockfish (*Sebastes caurinus*) and Gopher Rockfish (*Sebastes carnatus*). The remaining 82% of recaptured fishes were caught within the MPA near where they were initially tagged. These tag-recapture data provide a best estimate of spillover rates in central coast MPAs, however differences in sampling effort inside and outside of MPAs, and under-reporting of tagged fishes likely influence the actual spillover rate. Our results suggest that central coast MPAs are meeting conservation objectives by protecting species within their borders and still allowing spillover for fisheries augmentation.

AN INTEGRATED MPA DATA DASHBOARD TO SUPPORT MPA ASSESSMENT AND RESEARCH IN A CHANGING OCEAN (YOUTUBE)
Low, Natalie HN†; La Valle, Florybeth F; Ruhl, Henry A; Anderson, Clarissa R

1- Central and Northern California Ocean Observing System 2- Southern California Coastal Ocean Observing System

California’s statewide MPA network was established, with the goals of protecting marine populations, habitats, and ecosystems, improving fisheries sustainability, and enhancing coastal recreation, economies, and heritage. The 2022 state decadal review of the MPA network aims to assess its success in achieving these goals. However, state waters, including MPAs are impacted by different drivers across many temporal and spatial scales, including resource use, climatological and oceanographic variability, and long-term climate change. This presents a challenge in understanding the patterns and drivers affecting short- and long-term trajectories of change in MPAs. The Central and Northern California Ocean Observing System (CeNCOOS) and Southern California Coastal Ocean Observing System (SCCOOS) have integrated climatological, oceanographic, ecological, and model output data from multiple sources to develop an MPA Dashboard for exploration, access, and visualization of MPA-relevant data to support researchers and managers. These take the form of a set of integrated Shiny applications in R: (1) Environmental and Ecological Time Series, (2) Projected Climate Change Indicators, (3) Ecological Models, (4) MPA Connectivity. Here, we present the use of these tools, as well as ongoing analyses on MPAs and climate refugia in California state waters.

EXTERNAL FISHING EFFORT REGULATES POSITIVE EFFECTS OF NO-TAKE MARINE PROTECTED AREAS (YOUTUBE)

1- Moss Landing Marine Labs 2- Center for Coastal Marine Sciences, California Polytechnic State University 3- Oregon Department of Fish and Wildlife, Marine Resources Program 4- Marine Protected Areas Management Project, California Department of Fish and Wildlife

Marine protected areas (MPAs) have been established across the globe to mitigate the effects of multiple stressors on marine communities. In many locations, MPAs have positive effects on fish abundance, biomass,
and diversity; however, these effects vary across space and time. Factors driving variability in the strength of MPA responses among multiple locations are unknown, although fishing pressure, environmental conditions, and habitat differences are suspected sources. We examined changes in total fish biomass inside and outside of four no-take MPAs over 14 years in central California, USA using data from the California Collaborative Fisheries Research Program. We tested whether net primary production, sea surface temperature, and fishing effort influenced the strength of the MPA response observed. While temperature and productivity were included in the best model, fishing effort explained most of the spatial variation in MPA responses. Specifically, the difference in fish biomass between MPAs and sites open to fishing was larger for reserves near heavily fished locations. As MPAs continue to be used as a prominent conservation strategy in coastal systems, managers should consider both the suite of human-induced (socio-ecological interactions) and environmental conditions that may alter MPA success as well as establish long-term monitoring programs to fully assess the functionality marine reserves into the future.

INVESTIGATING THE ROLE OF COMMUNITY AND CITIZEN SCIENCE IN CALIFORNIA’S MPAS (YOUTUBE)
† Korabik, A.R.; Meyer, R. M.; Harwell, T. A.; Peterson, N. A.; Ballard, H. L.
1- UC Davis Bodega Marine Laboratory 2- UC Davis Center for Community and Citizen Science

For more than a decade, community and citizen science (CCS) projects of many kinds have played a prominent role in MPA activities, providing significant value to the State of California. CCS is relevant to multiple goals of the Marine Life Protection Act (MLPA) such as understanding ecological performance, promoting research and education, and even effective enforcement, but we currently lack a comprehensive view of how CCS has met that potential. Over the past few months, our team has aggregated existing data about CCS programs related to MPAs, focusing on the four main topics of 1) participant contributions and outcomes, 2) MPA program priorities and goals, 3) CCS program approaches, changes, and needs, and 4) the cross-cutting theme of diversity, equity, and inclusion. This talk will present results from the first phase of our project, including insights about state-funded CCS projects associated with MPA Baseline and Long-Term monitoring. In particular, we will present trends in participant numbers and effort by year and MPA region (North, Central, or South Coast) and the alignment of CCS activities with the main 4 pillars of MPA management (science and monitoring, education and outreach, policy and permitting, and enforcement and compliance). Moving forward, we expect our work to directly benefit participating CCS projects by: 1) raising the profile of marine and coastal CCS within the MPA program, 2) providing practical insights that programs can use in their projects, and 3) helping to envision and plan the next ten years of CCS in California’s MPA implementation.

DOES MPA AGE MATTER? FISH COMMUNITY COMPOSITION AND SIZE STRUCTURE WITHIN THE NEW AND OLD POINT LOBOS STATE MARINE RESERVE (YOUTUBE)
Moss Landing Marine Laboratories

In 1973, 750 underwater acres offshore of Point Lobos State Natural Reserve, CA were designated as a marine reserve. In 2007, the reserve was greatly expanded in size following the implementation of the statewide marine protected area (MPA) network along the Central California coast, providing a unique opportunity to compare changes in fish communities between a new and old reserve. A 2015 study using data from the California Collaborative Fisheries Research Program (CCFRP) found distinct differences in fish community composition between the new and old MPA areas in the first five years after expansion. Using seven more years of data, we reexamined whether differences remained between the old and new reserve areas, or if fish communities in the newer MPA now resemble those in the old MPA. Our results indicated that there are no differences in fish community composition between the new and old areas. We also examined whether the size structure of Blue Rockfish (Sebastes mystinus) and Gopher Rockfish (Sebastes carnatus) populations varied between the new and old areas. Soon after the MPA implementation (2007 – 2010), body sizes of both species were larger inside the old MPA than in the new MPA. However, in recent years (2017 – 2020), there was no difference in size structure between the old and new MPA areas detected. Our results suggest that 14 years of protection has been sufficient time for fish communities in the new MPA to resemble those in the old MPA.
Session 4: Population Biology and Ecology / Reproduction, Dispersal, and Recruitment

* indicates presenting author, † indicates eligibility for Best Student Paper Award

UTILIZING A MULTIYEAR DATASET OF UNOCCUPIED AIRCRAFT SYSTEM IMAGERY TO VALIDATE LANDSAT DERIVED GIANT KELP CANOPY (YOUTUBE)
Bell, T.W.; McPherson, M.L.
1- Woods Hole Oceanographic Institution 2- UC Santa Cruz

Long-term and large-scale monitoring of aquatic systems is crucial for detecting changes and drivers of ecosystems. Traditionally, satellites have been used for large-scale monitoring approaches because they can make observations at spatial scales from 10s to 100s of kms. Small unoccupied aircraft systems (sUAS) have recently emerged as a valuable remote sensing tool because they are logistically flexible and reduce challenges associated with the validation of satellite imagery. Utilizing a unique four-year dataset of near-simultaneous matchups of sUAS color imagery and Landsat multispectral data, we investigated methodological behavior and results from an automated classification and spectral unmixing approach developed for a multi-decade timeseries of giant kelp canopy. We focused on aspects that influence estimates of kelp canopy at the pixel and kelp bed scale, including spatio-temporal variability in ocean conditions, and the spectral unmixing and classification of kelp versus seawater. We found that pre-classification of kelp and seawater is necessary from a quality control perspective because MESMA can be noisy across Landsat sensors, but that it resulted in higher uncertainty of kelp canopy from sparse beds. Therefore, we can expect more error in Landsat MESMA estimates when observing low canopy biomass or fringing kelp bed conditions that result in low pixel canopy fractions. This study provides broader context for validation approaches to satellite derived timeseries by utilizing a unique multiyear dataset and exploring pixel and patch-scale uncertainties.

CAN RESTORING AGE STRUCTURE BUFFER SACRAMENTO RIVER CHINOOK SALMON AGAINST CLIMATE VARIABILITY (YOUTUBE)
Carvalho, P.G.; Palkovacs, E.; Satterthwaite, W.; O’Farrell, M.; Speir, C.; Bellanger, M.
1- UCSC, NOAA 2- UCSC 3- NOAA 4- IFREMER

Juvenile salmon survival during migration to marine systems depends on sufficient river flows. However, freshwater resources are becoming increasingly variable with climate change. The current drought in California serves as a prime example, where low flow in the Sacramento River prompted the release of millions of hatchery salmon directly into San Pablo Bay and San Francisco Bay to circumvent low juvenile survival rates in dry conditions. Historically, diverse age structure and life histories enabled California Central Valley salmon populations to persist through extreme climates by spreading risk across age classes and thus water years. Yet, Pacific salmon populations are losing age structure and becoming more homogenized due to anthropogenic disturbances such as fishing and habitat degradation. We tested the hypothesis that more diverse age structure buffers Sacramento River fall Chinook (SRFC) salmon against extreme flow variability. We constructed a life-cycle population dynamics model for SRFC that includes flow-dependent juvenile survival to quantify mean and variability of spawner escapement. For different combinations of flow and age structure, we estimate the frequency distribution of allowable harvest rates given the existing harvest control rule for SRFC. Preliminary simulations indicate that a more diverse age structure results in lower variability in spawner escapement and constraints to fisheries under conditions of recurring drought. These results reveal potential benefits of restoring age structure as climate change alters water availability.

GENOME-WIDE MARKERS REVEAL DIFFERENTIATION BETWEEN AND WITHIN THE CRYPTIC SISTER SPECIES, SUNSET AND VERMILION ROCKFISH (YOUTUBE)
1- NWFSC 2- SWFSC

The vermilion rockfish complex, which consists of the cryptic sister species vermilion and sunset rockfish, is one of the most valuable recreational fisheries on the U.S. West Coast. These species are currently managed as a single complex, and because of uncertainty surrounding the relative contribution of each species within existing data sources, the stock status of each species is not fully known. A reliable and cost-effective method
is needed to disentangle these species that will allow for the development of abundance indices, life history profiles, and catch histories that may support species-specific stock assessments. Using RADseq, we generated 10,003 polymorphic loci to characterize the complex. PCA and Bayesian clustering approaches based on these loci clearly distinguished between species and identified hybrid individuals. These loci included 203 highly differentiated \( F_{ST} \geq 0.99 \) SNPs, some of which were incorporated into a diagnostic assay. In addition to clearly delineating to species, subsets of the interspecific markers allowed for insight into intraspecific differentiation in both species. Population genetic analyses for sunset rockfish identified two weakly divergent genetic groups with similar levels of genetic diversity. Vermilion rockfish, however, were characterized by three distinct genetic groups with much stronger signals of differentiation and significantly different genetic diversities. Collectively, these data will contribute to well-informed, species-specific management strategies to protect this valuable species complex.

**SYNTHESIS: WHAT WE’VE LEARNED FROM THE SEA STAR WASTING SAGA (YOUTUBE)**

Schiebelhut, L.M.\(^1\); Giakoumis, M.; Oulhen, N.; Hewson, I.; Raimondi, P.T.; Wares, J.P.; Dawson, M.N

1- UC Merced 2- City University of New York 3- Brown University 4- Cornell 5- UC Santa Cruz 6- University of Georgia, Athens

The sea star wasting (SSW) outbreaks first gaining widespread attention in 2013 along the US west coast have highlighted gaps in our basic knowledge about the afflicted asteroids. To begin to fill these gaps, we assembled a group of 36 scientists with broad expertise to synthesize what we have learned from the SSW pandemic along four axes by (1) providing an overview of sea star biology, (2) contextualizing SSW in a phylogenetic framework and testing for associations with natural and life-history traits, (3) evaluating environmental impacts on SSW at small and broad geographic scales, and (4) assessing the genomic consequences of mass mortality. Although coarse at times, one of our aims was to broaden the diversity of asteroids represented in the literature, beyond the subset of data-rich species. Highlighting some of our results, we find that species with elevated SSW impacts generally occur at shallower depths and have an earlier (spring) reproductive season relative to less impacted species. Environmental factors contributing most to SSW appeared to be elevated SST and decreased wave exposure. Long generation times and periodic recruitment in some species may mean the genetic consequences of a massive die-off may not be evident for many years. Fully understanding SSW remains challenging, in part because gaps still exist in the asteroid phylogeny and in our understanding of the basic biology of asteroids. In a period of unprecedented rapid climate change, understanding how species respond to new extremes at various scales may be essential to mitigating their impacts.

**POPULATION ECOLOGY OF AN ANTIPATHARIAN FOUNDATION SPECIES: BLACK CORALS IN THE GALÁPAGOS MARINE RESERVE (YOUTUBE)**

† Agarwal, M.M.; Smith, F.; Lamb, R.; Witman, J.D.

Brown University

*Antipathes galapagensis* is a prevalent habitat-forming black coral that is thought to be an important foundation species in subtidal ecosystems of the Galápagos Marine Reserve (GMR). With their arborescent morphologies, black corals create 3D relief in an otherwise exposed environment, providing a physical refuge for marine biodiversity. Despite their ecological importance and status as a CITES-regulated species, the depth distribution, population structure, and general ecology of this species has yet to be examined in the GMR. Here, 656 corals at 9 sites across the central archipelago of the Galápagos were surveyed to quantify how black coral populations vary across a depth gradient. Using band transects and occupancy modeling we found that coral density and height increase with depth, that corals in shallow water display more cryptic habitat usage than those at depth, and that the composition of epibiont communities overgrowing coral colonies changes with depth. Further, though the majority antipatharian species reside below the photic zone (>50m depth), our surveys showed that populations of black corals in the GMR are among the shallowest in the world, with unusually high densities of corals recorded at <8m depth. In light of the important role of *Antipathes galapagensis* in GMR communities, this study functions as a baseline for evaluating change and informs management decisions regarding shallow water black corals in the Galápagos and Eastern Tropical Pacific.
EVIDENCE FOR GENETIC VARIATION UNDERLYING EELGRASS (ZOSTERA MARINA) LIFE HISTORY STRATEGY (YOUTUBE)
Briones Ortiz, B.A.; Ruesink, J.L.; Naish, K.A.

1- School of Aquatic and Fishery Sciences, University of Washington 2- Department of Biology, University of Washington

Eelgrass (Zostera marina) are indispensable ecosystem engineers in estuarine habitats and can display dramatic trait variation. Annual life histories in eelgrass occur when plants germinate and form generative shoots within a single growing season. These annual ecotypes have been recognized for decades, from many different parts of the broad range of this seagrass, including The Netherlands, Korea, and the US West and East Coasts. Early genetic work based on allozymes indicated that annual (100% flowering) and perennial (low-flowering frequency, predominantly clonal reproduction) phenotypes shared a similar genetic background, but no recent work exists comparing life history types using modern genomic approaches. We investigated patterns of genetic variation associated with cooccurring life history strategies in eelgrass. Using ~400 SNPs, we performed population genetic analyses on 182 shoots sourced from pairs of neighboring annual and perennial meadows located in two distant areas within an estuary. Perennial populations situated 12 km apart were genetically indistinguishable, but genetically different from nearby (ca. 250 m) annual populations, that is, annual populations were more genetically similar to each other than to their perennial neighbors.

CORRELATES OF BIOLOGICAL PRODUCTION ACROSS THE METAZOA (YOUTUBE)
† Ginther, S.C.; Cameron, H.; White, C.R.; Marshall, D.J.

Monash University

Biological production, or the creation of new somatic or reproductive tissue, underpins all ecosystem services that humans rely upon. Any changes to production will have consequences for food security, the global carbon pump, and ecosystem function. While body size is well recognised as a strong predictor of production, remarkably, there is no consensus on how production relates to size, nor do we understand how this relationship varies across different groups and environments. Rates of production are assumed to depend on temperature, but the evidence supporting this assumption is remarkably scarce. We compiled adult body size, environmental temperature, and reproductive mass (i.e., biological production) for more than 8000 species spanning the full range of metazoan body sizes, from rotifer to blue whale. Reproductive mass scaling was hypallometric – larger species produced much less reproductive mass relative to their body size than smaller species. While warmer temperatures generally decreased reproductive mass, warming differently affected reproductive scaling of major clades. Our results highlight that larger animals are less productive than smaller animals relative to their size, and that future warming may affect the biological production of major clades unequally.

UNIQUE DISTRIBUTION AND ACOUSTIC RESIDENCY PATTERNS OF SYMPATRIC MAMMAL-EATING KILLER WHALE POPULATIONS IN THE GULF OF ALASKA (YOUTUBE)
† Myers, H.J.; Olsen, D.W.; Matkin, C.O.; Konar, B.

1- College of Fisheries and Ocean Sciences, University of Alaska Fairbanks 2- North Gulf Oceanic Society

Mammal-eating transient killer whales (Orcinus orca) are top predators in the North Pacific Ocean. In the northern Gulf of Alaska, two sympatric, genetically and acoustically distinct transient populations play unique roles in the marine ecosystem through differential prey selection and habitat use patterns. Understanding their distribution and residency provides insight into drivers of habitat selection and is important to management of this federally protected species. However, these cryptic animals are rarely documented in vessel surveys. In this study, we used passive acoustic monitoring to provide the first description of year-round distribution and acoustic residency patterns of the Gulf of Alaska transient and AT1 transient killer whale populations. These findings provide insight into the importance of different areas throughout the year and possible foraging behavior. We also uncovered the first group of discrete calls that can be used to identify the Gulf of Alaska transient population in passive acoustic research. This study underscores the advantages of passive acoustic monitoring in researching marine mammals such as transient killer whales.
DISPERAL AND CONNECTIVITY IN A RARE SPECIES OF ANEMONEFISH (PREMNAS BIAOCULEATUM) WITH APPLICATIONS TO CONSERVATION (YOUTUBE)
† Fitz, K.S.¹; Montes, H.R.; Thompson, D.M.; Pinsky, M.L.
1- Rutgers University 2- Visayas State University 3- University of Arizona

Obtaining estimates of dispersal for species is key to understanding local adaptation, population dynamics, and to implementing conservation actions. Genetic isolation-by-distance patterns can be used for understanding dispersal, and these patterns are especially useful for marine species in which few other methods exist for measuring dispersal distances. In this study, we genotyped eight populations of a coral reef fish (Premnas biaculeatus) at 16 microsatellite loci to generate fine-scale estimates of dispersal. All populations except for one followed isolation-by-distance patterns. Linkage disequilibrium estimates suggest a mean density of 53 fish/km. Using isolation-by-distance theory, we estimate a larval dispersal spread of 8.9 km [95% confidence interval of 2.3-18.4 km]. Genetic distance to the remaining population did not correlate with geographic distance, but did correlate strongly with the probability of larval dispersal from an oceanographic model. Ocean currents were a better predictor for genetic distance at large spatial scales (populations greater than 150 km apart), while geographic distance remained the best predictor for spatial scales less than 150 km. Our study demonstrates how isolation-by-distance patterns can be implemented along with oceanographic simulations to understand connectivity in marine environments and to develop marine conservation strategies for coral reef ecosystems.

RAPID GENOTYPING METHOD ENABLES ASSESSMENT OF SPATIOTEMPORAL VARIATION IN RECRUITMENT OF NATIVE AND INTRODUCED MULLET IN HAWAII
† Laliberte, S.M.¹; Iacchei, M.J.
Hawaii Pacific University

Based on transgenerational Hawaiian fishpond knowledge, yearly abundances of ‘ama’ama (Mugil cephalus) mullet recruits in Kāne‘ohe Bay has been declining since 1965. In Hawai‘i, ‘ama‘ama reach sexual maturity around 3 years of age, & spawn once or twice during the winter months, with larvae recruiting to estuarine habitats in spring. In contrast, the introduced kanda mullet (Osteomugil engeli) reach maturity in the first year & are hypothesized to spawn/recruit year-round. Juveniles under 7 cm are difficult to distinguish morphologically between species. We designed a 3 PCR-primer method to aid in non-destructive & rapid genetic identification of recruit-sized mullet to validate species-specific recruitment patterns across 3 sites in Kāne‘ohe Bay. Here are the results from the first 6 months of sampling. Environmental gradients, CPUE data, & species proportions indicate that ‘ama‘ama recruit to habitats with more freshwater influx, while kanda recruit to habitats with a broader salinity range. In field observations show the dorsal edge of ‘ama‘ama has a black hue, whereas the kanda’s dorsal side is lighter with larger scales. To date, ‘ama‘ama recruits were dominant in April & May, but kanda recruits have been the dominant species from June-September. However, ‘ama‘ama recruit numbers in summer & fall support a broader recruitment period for ‘ama‘ama outside of the early spring. Pairing this DNA-typing method with fishpond caretaker knowledge & observations of recruit arrival times greatly improves the spatiotemporal accuracy of fish recruitment estimates.

Session 5: Intertidal Ecology II

* indicates presenting author, † indicates eligibility for Best Student Paper Award

HOW DO OCEANOGRAPHIC CONDITIONS AFFECT THE RECOVERY OF CORALLINE ALGAL COMMUNITIES FOLLOWING DISTURBANCE (YOUTUBE)
† Fulton-Bennett, H.K.
Oregon State University

Crustose coralline algae are ecologically important calcifying algae found globally from kelp forests to coral reefs, but are often overlooked due to their small size and cryptic habit. As major marine calcifiers, they are negatively impacted by ocean acidification and abundances are expected to decrease dramatically under future ocean conditions due to increasing energetic costs of calcification. Coralline algae provide essential
ecosystem functions such as cementing together cobbles and coral rubble to stabilize reefs, providing habitat for numerous invertebrates and algae, and producing a chemical settlement cue used by invertebrates such as corals, sea urchins, and sea stars. While populations are predicted to decline worldwide due to ocean acidification and increasing disturbance, high nutrient levels in areas of frequent upwelling may mediate the negative effects of low pH and increasing temperatures. I compared the coralline algal recovery in areas of frequent upwelling to those dominated by downwelling and monitored the temperature and pH across the range of conditions. Preliminary results suggest that coralline algae are able to recover from disturbance more quickly in areas of upwelling, despite lower temperatures and pH. While upwelling regions may provide areas of refuge for coralline algae on some coasts, these effects may be transient as climate change exacerbates extreme conditions. Due to the importance of coralline algae in ecosystem structure and function, we need better understand how these communities will change under future ocean conditions.

**Big Shoes to Fill: Potential Compensatory Effect of Small Predators Following Keystone Predator Loss**

Gregory, S.E.*; Bachhuber, S.M.; Menge, B.A.

*Oregon State University*

Sea Star Wasting Syndrome (SSWS) decimated populations of *Pisaster ochraceus* throughout rocky intertidal habitats on the North American west coast. In the absence of predation by *Pisaster*, other predators may be able to suppress mussel bed expansion. One candidate predator is *Leptasterias hexactis*, a small sea star that was less profoundly affected by SSWS. We asked whether *Leptasterias* can prevent mussel takeover in the absence of *Pisaster* in two well-studied Oregon rocky intertidal habitats. We conducted a cage experiment with two treatments: one excluding all predators and grazers, and one with only *Leptasterias* included in the cage. After 18 months, we analyzed community structure and abundance of organisms using photo plot analysis and by sorting biomass samples to the functional group level. Preliminary results suggest that the ability of *Leptasterias* to compensate for *Pisaster* was highly variable: strong at one site and weak at another. *Leptasterias* suppression of mussel bed growth within cages is likely dependent on invertebrate recruitment patterns, providing important insight into the dynamics of intertidal food webs after a disease outbreak. Understanding how marine ecosystems respond to disease is becoming increasingly important as outbreaks are predicted to increase in both duration and frequency with the progression of climate change.

**Does History of Exposure to Aerial Stress Impact Intertidal Mussels’ Recovery Period?**

† Kalbach, G.M.*; Miller, L.P.

*San Diego State University*

Microhabitat characteristics play an important role in determining how sessile intertidal organisms experience their environment. Settling in a tide pool allows mussels to remain submerged throughout the tidal cycle, while settling outside of a pool leads to aerial exposure during low tides. Mussels within a tide pool may experience more consistently favorable conditions, however, when a pool drains and mussels are exposed to air, these individuals may be less equipped to deal with this new stressor and may face prolonged recovery periods in comparison to their frequently exposed counterparts. A well-documented metric for determining physiological response to stress is heart rate. Following exposure to air, mussels are expected to display elevated heart rates as they recover from the oxygen debt acquired during exposure. Mussels that face this stressor less frequently are expected to have prolonged recovery periods. To monitor the aerial stress response of a common intertidal mussel species, 32 *Mytilus trossulus* individuals in the field were fitted with infrared heart rate sensors in summer 2020 to continuously monitor heart rate and external body temperature non-invasively. We tracked individual temperature and heart rate across multiple days to look for differences in individual responses to aerial exposure. The length of the recovery period (defined as an elevated above normal heart rate) is compared between frequently exposed mussels and scarcely exposed mussels.

**Effects of P. Ochraceous and Bird Predators on Intertidal Community Recovery Following a Disease Outbreak**

Miller, N.M.*; Menge, B.A.; Poirson, B.N.; Field, L.C.; Robinson, J.W.; Gravem, S.A.

*Oregon State University*
The 2013-15 mass mortality of Pisaster ochraceous due to Star Wasting Syndrome (SSWS) enabled us to test the mechanisms of resilience to the absence of a keystone predator and the importance of top-down control within rocky intertidal ecosystems. Specifically, we asked if it was possible for seabirds, another large predator within the intertidal, to compensate as predators following the loss of the keystone predator P. ochraceous due to SSWS. To answer this question, we cleared 25 20x20cm plots in 2018 at each of 10 sites along the Oregon and Northern California coast. We applied five treatments to the plots using steel mesh cages, allowing or disallowing P. ochraceous and/or seabirds to access each plot and prey upon the organisms settled within them. After 1.5 years, we collected and measured the biomass of different taxa within the plots to understand if and how the two predators affected intertidal community recovery. At the two sites we have analyzed so far, the recovered populations of P. ochraceous affected the biomass of the community but birds did not, indicating that seabirds were not able to compensate as predators in the absence of P. ochraceous. Additionally, the effects of P. ochraceous were unsurprisingly more apparent on their prey species mussels and gooseneck barnacles. These results help us gain a better understanding of the nature of P. ochraceous’ role as a keystone predator, along with the significance of top-down community control within the intertidal following disturbances such as SSWS.

DONAX GOULDII DOES SWASH-RIDE WITH THE TIDES, POTENTIALLY MANIPULATED BY PARASITES

Nelson, A.P.*; Hechinger, R.F.

*Scripps Institution of Oceanography

For decades there have been conflicting anecdotal accounts as to whether the bean clam, Donax gouldii, actively migrates with the tides. Most sources claim that bean clams maintain a fixed intertidal position, unlike other Donax species. However, we have repeatedly observed that the clams do appear to migrate at Scripps Coastal Reserve, prompting us to investigate the extent of and mechanisms behind their movement. Additionally, upon dissection of ~1,500 bean clams, we learned that 100% were infected with trophically transmitted stages of the trematode parasite, Postmonorchis donacis. We hypothesized that the parasite may manipulate clam behavior, causing them to move to lower elevations to increase the parasite’s transmission to final host fish. Over 4 months we used elevational transects and coring to quantify the density, distribution, and parasite load of bean clams at Scripps beach across a range of elevations and tides. To observe the mechanisms underlying clam migration, we took video recordings in the intertidal zone. We observed the clams actively migrating shoreward on rising tides and seaward on falling tides, shifting the majority of clams to higher and lower elevations during high and low tides, respectively. As predicted, clams at lower elevations tended to have 35 – 48% more P. donacis metacercariae than clams at higher elevations, despite there being no elevational gradient in the source of infectious stages. While the parasite’s manipulative role requires further study, the bean clam does perform active swash-riding to migrate with the tide.

AN INVASIVE SPECIES ERODES THE PERFORMANCE OF COASTAL WETLAND PROTECTED AREAS

† Ren Junlin*; He Qiang

*Fudan University

The world has increasingly relied on protected areas (PAs) to rescue highly valued ecosystems from human activities, but whether PAs will fare well with bioinvasions remains unknown. By analyzing three decades of seven largest coastal PAs in China, including multiple World Natural Heritage and/or Wetlands of International Importance sites, we show that, although PAs are achieving success in rescuing iconic wetlands and critical shorebird habitats from once widespread reclamation, this success is counteracted by escalating plant invasions. Plant invasions were not only more extensive in PAs than non-PA controls but also undermined PA performance by, without human intervention, irreversibly replacing expansive native wetlands (primarily mudflats) and precluding successional formation of new native marshes. Exotic species are globally invading PAs. This rare study across large spatiotemporal scales highlights that the consequences of bioinvasions for humanity’s major conservation tool may be more profound, far reaching, and critical for management than currently recognized.

Independent effects of carbonate chemistry and salinity on growth of adult mussels
Coastal bivalves experience high seawater chemical variability in nature, with consequences for their ability to calcify their protective shells. Over longer time scales, chemical changes due to ‘ocean acidification’ arise as human-produced CO$_2$ enters seawater. Coastal habitats also experience shorter-term chemical variation due to freshwater inputs, including shifts to both salinity and alkalinity. Because watersheds with differing geology and productivity express unique salinity-alkalinity relationships, riverine fluxes drive a mosaic of coastal alkalinity and salinity concentrations. Prior research, however, has largely neglected spatial gradients and distinct effects of alkalinity and salinity on shoreline organisms, leaving gaps in our understanding of how coastal bivalves respond to these two factors, independently and in combination. Focusing on Mytilus californianus (the California mussel), a common habitat-forming species along the coast of North America, we explored the relative and joint effects of salinity and alkalinity on shell production by this species. Our data suggest that salinity and alkalinity operate as independent controls on calcification. In particular, calcification rates are elevated when alkalinity is high, even in low-salinity treatments. This approach can be used to explore how diverse sources of freshwater may impact shell building in coastal calcifiers that simultaneously face global shifts in seawater chemistry due to ocean acidification.

THE EFFECT OF CLIMATE CHANGE ON A CANOPY-FORMING ROCKWEED AND ITS ASSEMBLAGE

San Diego State University

Foundation species shape community composition and enhance biodiversity and ecosystem productivity. For example, canopies of the intertidal seaweed, Silvetia compressa, support a diverse seaweed understory. Such assemblages may be particularly susceptible to global climate change (GCC) because of the potential for both direct effects and indirect effects of disturbance (e.g. foundation species loss). Indirect effects of GCC on Silvetia communities could become more common given the recent suggestion that ocean warming contributed to Silvetia loss in Southern California. Yet, these impacts are largely unknown given that research historically focused on population-level effects of GCC on seaweeds. To address this research gap, we used flow-through mesocosms to expose understory assemblages to seawater climate (current and two future projections of water temperature and pH) and Silvetia cover (Present/Absent). Silvetia photosynthetic efficiency and growth worsened with climate severity. The impacts on the growth of understory seaweeds were complex, including species-specific responses and interactions of climate and Silvetia cover. Thus, projected climates influenced the growth of a canopy-forming foundation species seaweed and of some understory seaweeds when tested in realistic assemblages.

INTERACTIONS BETWEEN NORTHERN KELP CRAB (PUGETTIA PRODUCTA) AND BULL KELP (NEREOCYSTIS LUETKEANA)

Kelp forests are very important habitats with high biodiversity that provide many ecosystem services. With increasing anthropogenic stressors, including marine heatwaves, increased frequency and intensity of storms, and changes to the complex community, this system is being threatened by potential deforestation. One type of forest that is common off of the coast of Washington in the Salish Sea is bull kelp (Nereocystis lutkeana). Previous studies of this ecosystem have shown that sea urchins (Strongylocentrotus franciscanus and S. purpuratus) play a large role in shaping this community. One of the less investigated but potentially influential herbivores is the Northern kelp crab (Pugettia producta). My experiment seeks to connect feeding experiments that are done in the laboratory to kelp crab surveys in the field by creating artificial kelp forest and examining the interaction between the bull kelp at different life stages and the Northern kelp crab. In my experiment I placed a kelp crab in an artificial kelp forest that was constructed in a tank with either one adult, one adult and two juveniles (mixed), or four juvenile bull kelp. I then tracked the location and hiding behavior of the crab in the adult and mixed tanks for eight hours. The crabs spent most of their time on
the blades of the adult bull kelp, sometimes were not on the kelp at all, and rarely clung on to the stipes. In the adult tanks, the kelp crabs were often hiding, however in the mixed tanks, the crabs hid less. For the juvenile kelp, which possibly represent a more vulnerable life stage, I quantified

Session 6: Community Ecology II / Applied Ecology

* indicates presenting author, † indicates eligibility for Best Student Paper Award

DRIVERS OF ZOOPLANKTON COMMUNITY COMPOSITION IN A NOVEL ECOSYSTEM: HAWAII MANGROVES AS A CASE STUDY (YOUTUBE)
Granek, EF1*; Lewis, CL 1- Portland State University 2- PSU

Management of established non-native plants is challenging because removal is expensive and can produce negative consequences, yet establishment can create novel ecosystems. Red mangrove propagules were introduced to Moloka‘i, Hawai‘i, in 1902 to mitigate the effects of soil erosion and have spread along the coast and to adjacent islands creating novel habitat. We compared zooplankton communities between novel mangrove and historical non-mangrove habitat both within fishponds and along open coastline to examine environmental factors, including mangrove presence, affecting zooplankton community composition. Community composition patterns were driven by lunar cycle and site characteristics - fishpond structure, mangrove and open-coast shoreline length, percent of mangrove shoreline length, total percent mangrove leaf carbon and upstream watershed disturbance. Our findings indicate that during the tropical summer reproductive season, non-native mangroves support diversity, richness and community composition similar to non-mangrove areas, though some widespread taxa have lower abundance, and some rare taxa are more abundant in mangroves. Additionally, fishpond zooplankton community structure is significantly different from open-coast areas, indicating fishponds, themselves, create novel habitat. In the face of declining fisheries, threatened reef habitat and changing climatic conditions, non-native mangroves may provide, rather than impede, zooplankton habitat availability in novel locations.

ATMOSPHERIC PERSISTENCE OF REFLECTIVE AEROSOLS TEST #2: HAYABUSA SPACECRAFT FASTEST RE-ENTRY, WITH ABLATIVE ORGANIC HEAT SHIELD
Kitting, C.L.*

Biol. Sci., Cal State U. East Bay

Meteors, possibly man-made satellites, and experiments can directly introduce upper atmospheric aerosols, hypothetically reflective enough to cool Earth. Our team monitored a second major satellite reentry, an unusually fast but small Japanese Hayabusa spacecraft (1m3) and capsule (a 40-cm hemisphere with ablative organic heat shield) re-entering Earth’s atmosphere into remote Woomera Missile Range, South Australia. I simultaneously sought persistence of resulting aerosols through Earth’s atmosphere. With my customized portable equipment, Hayabusa’s 1m3 bus appeared at its initial re-entry 5 sec before its asteroid sample-return capsule. Tracking bus fragments and capsule showed them continuously until fading out 59 sec later, ~80 degrees across our night sky, to our eastern horizon. After the capsule reached detectability at 105 km elevation, a detectable trail appeared 14.9 sec later. My HD infrared video frames covering sharp 15-degree fields, once enhanced, detected an irregularly pulsing trail from the capsule. But detectable trails lasted <2 seconds, only. Seven hours later, at dawn, even direct sunlight through the atmosphere failed to detect any persistent, reflective aerosols from this unusually fast reentry through Earth’s entire upper atmosphere. Aerosols from even fast spacecraft apparently do not persist long enough to provide detectable reflection in Earth’s atmosphere. Rather than such possible cooling of Earth, we might use proper education and extreme conservation to correct our exceeded carrying capacity, soon.

CALIBRATING ENVIRONMENTAL DNA METABARCODING FOR FISH SPECIES RICHNESS (YOUTUBE)
† McElroy, M.E.*

UC Santa Barbara
Proper identification of species present in a landscape is foundational to ecology and essential for natural resource management and conservation. However, many species may be missed during direct capture and visual surveys, especially in aquatic environments. Environmental DNA metabarcoding is an approach that overcomes low detection probabilities and should consequently enhance estimates of biodiversity and its proxy, species richness. We synthesized 37 studies in natural aquatic systems to compare species richness estimates for bony fish between eDNA metabarcoding and conventional methods, such as nets, visual census, and electrofishing. In freshwater systems with fewer than 100 species, we found eDNA metabarcoding detected more species than conventional methods. Using multiple genetic markers further increased species richness estimates with eDNA metabarcoding. For more diverse freshwater systems and across marine systems, eDNA metabarcoding reported similar values of species richness to conventional methods; however, more studies are needed in these environments to better evaluate relative performance. In systems with greater biodiversity, eDNA metabarcoding will require more genetic reference sequences, increased sampling effort, and multi-marker assays to ensure robust species richness estimates and further validate the approach. With continued advances, eDNA metabarcoding will facilitate broader biodiversity assessments that can outperform conventional surveys for estimating species richness.

**LONG-TERM EFFECTS OF OCEAN ACIDIFICATION ON RED ABALONE (HALIOTIS RUFESCENS) GROWTH AND PERFORMANCE** *(YOUTUBE)*

† Neylan, I. P.*; Swezey, D. S.; Boles, S. E.; Sih, A.; Stachowicz, J. J.

1- University of California, Davis Bodega Marine Laboratory 2- University of California, Davis

Ocean acidification (OA) poses a growing threat to the sustainable commercial production and restoration aquaculture of red abalone (*Haliotis rufescens*). Larval and early life stages of abalone have been shown to be particularly susceptible to OA. However, little is known regarding the long-term effects of OA on abalone’s bi-phasic lifespan and in particular whether there are potential carryover effects from early life exposure into adulthood. Using an advanced OA-manipulation system, offspring of farm-sourced abalone (F0, raised in ambient conditions and bred to create the F1 generation) were exposed (split-brood design) to OA and control pH conditions during early life stages (0-3 months) and then allowed to reach maturity in ambient common garden conditions (4 years). We then placed these F1 adults from different maternal (F0) families previously found to be either resilient or vulnerable to OA during early life back into OA or control pH for a fully factorial design. Abalone remained in the system for 11 months after which we measured growth and reproductive potential using ultrasonography. We found that early life exposure to OA created lasting negative effects on growth especially when adults were again exposed to OA, but that only adult experience with OA negatively impacted reproductive potential regardless of early life exposure. These patterns were family dependent with OA-vulnerable families displaying less detrimental OA effects suggesting that differential selection in early life along with stress legacy may contribute to adult abalone performance.

**RESOURCE PARTITIONING WITHOUT COMPETITION IN CORAL-REEF FISHES** *(YOUTUBE)*

† Jones, R. N.*; Hixon, M. A.

*The University of Hawai‘i at Mānoa*

Coral reefs on exposed coastlines in Hawai‘i are dominated by cauliflower coral (*Pocillopora meandrina*), whose branches provide habitat for a variety of fishes and invertebrates, including the Galactic Scorpionfish (*Sebastapistes galactacma*) and the Speckled Scorpionfish (*S. coniorta*). These species have overlapping depth ranges, Galactic Scorpionfish deeper and Speckled Scorpionfish shallower, and frequently inhabit coral colonies near one another, occasionally co-occupying the same colony. Because these species are ecologically similar, interspecific competition could be limiting their local distribution and abundance, in which case the removal of a putative competitor should lead to an increase in the local abundance of the remaining species. In 2019, we conducted a reciprocal-removal experiment using clusters of coral colonies but found no evidence of competition limiting either species, possibly due to the scale of the experimental units. In 2020, we began a year-long reciprocal-removal experiment using only colonies occupied by both species. The abundance of both species increased slightly immediately after removals but returned to pre-removal levels after about two months. These outcomes indicate that competition is not presently an important interaction
between these species despite their ecological similarity. One potential explanation for these patterns could be fine partitioning of food resources between the two species. Alternatively, severe recruitment limitation in Hawai‘i may lessen competition between these species, allowing coexistence.

**BIOTIC VARIATION IN A ROCKY SHORE PREDATOR-PREY INTERACTION**
† Longman, E.K.; Sanford, E.

UC Davis, Bodega Marine Laboratory

Until recently, marine ecologists neglected the potential importance of divergent natural selection acting on predator populations along the coast. *Nucella canaliculata* is a predatory snail that inhabits rocky intertidal ecosystems from central California to Alaska. Previous work has documented that this species is locally adapted to its prey communities. In particular, snails from California are able to drill mid-sized (5-7cm) *Mytilus californianus*, whereas those from Oregon generally cannot. However, the underlying mechanisms and scale of these phenotypic differences in drilling haven’t been determined. We hypothesize that mussel shell thickness varies spatially and may be driving adaptive divergence in drilling phenotypes. We hatched and raised *N. canaliculata* from 6 populations (3 in CA and 3 in OR) for a year on a diet of *M. trossulus*. Then, we challenged these snails with a series of *M. californianus* of increasing size (2, 4, 6, 9, 12, 15, 17cm) and shell thickness to identify the maximum drill hole depth of each snail. There were clear biogeographic differences in drilling capacity; snails from California populations were able to drill mussels that were more than double the size of those drilled by Oregon snails. Further, the maximum drill hole depth was significantly greater for California snails compared to those from Oregon. We are exploring whether selection on drilling capacity is associated with a coastal mosaic of mussel shell thickness and whether these differences might influence the dynamics of rocky shore communities.

**Comparing fish and invertebrate communities of two neighboring kelp communities, Macrocystis pyrifera and Egregia menziesii**
† Neary, S.E.; Wetmore, L.S.; Anderson, T.W.

Department of Biology and Coastal and Marine Institute, San Diego State University

Characterizing the relationship between the abundance or composition of species and the structural complexity of their habitats is a common goal of ecological studies, as habitat structure can be an important predictor of the distribution and abundance of a variety of terrestrial and aquatic taxa. Temperate rocky reefs in southern California are largely occupied by stands of the giant kelp, *Macrocystis pyrifera*, and extensive research has been conducted in *Macrocystis* forests surrounding its role as an important habitat-forming species. However, virtually no research has been conducted on stands of another prominent shallow-water macroalga, *Egregia menziesii*, or the fauna associated with these kelp forests. Here, we conducted a series of visual field surveys aimed at identifying and enumerating the fish and invertebrate communities associated with the feather boa kelp, *Egregia menziesii*, in comparison to the faunal assemblages associated with nearby *Macrocystis* forests. Species count and biomass data showed little difference in biomass and numerical densities of fish and invertebrates between kelp environments, however further analyses of community data does show significant differences in species composition between the kelp species, which is most notably driven by commercially important species. Differences in community composition appear to be driven more by habitat characteristics in *Egregia*, versus kelp characteristics and abundance as in *Macrocystis*.

**CLIMATE CHANGE, ENVIRONMENTAL GRADIENTS AND POPULATION SYNCHRONY**
† Samus, S.M.; Munch, S.B.; Dolan, T.E.; Rogers, T.L.

1- Hawai‘i Pacific University 2- University of California, Santa Cruz 3- Southwest Fisheries Science Center

Metapopulation synchrony is the correlation between abundances of metapopulations. Global warming is expected to increase metapopulation synchrony by flattening the latitudinal sea surface temperature (SST) gradient. To see if this is occurring for market squid on the coast of California, we quantified the synchrony of market squid biomass to examine whether synchrony has increased over time. Assuming that SST drives synchrony of market squid through the Moran effect, we also examined whether the latitudinal
gradient and synchrony of sea surface temperature had changed over time. Preliminary results show that
the synchrony of squid metapopulations ~200 km apart increased over the past 50 years. Across distances
less than 200 km and greater than 400 km, synchrony of squid populations increased from 1969-1987, after
which the synchrony decreased. The synchrony of SST through time decreased at several spatial scales and
the latitudinal gradient of SST flattened through time, both contrary to our expectations. Further work will
provide possible explanations for these observed patterns and examine how the synchrony of market squid
and SST on the east coast of the United States have changed through time.

THE TROPHIC ECOCOMY OF A UBQUITOUS KELP FOREST ECHINODERM, THE
BAT STAR (PATIRIA MINIATA) (YOUTUBE)
Cryan, D.M.1*; Low, N.H.; Litvin, S.Y; Osenberg, C.W.; Micheli, F.
1- University of Georgia 2- Monterey Bay Aquarium Research Institute 3- Stanford University

Echinoderms often play key roles in structuring marine ecosystems. The bat star (Patiria miniata) is an
abundant kelp forest echinoderm whose trophic ecology has been understudied. Understanding Patiria's
trophic role is important given the recent declines of many sea star populations due to wasting disease.
Patiria was largely unaffected by these outbreaks and could potentially fill the trophic niches left by other
ecologically important sea star species. In this study we used a combination of feeding experiments and stable
isotope analysis to provide new insights into the trophic ecology of Patiria miniata. Given Patiria's reputation
as an omnivorous generalist, we conducted a series of feeding experiments in which we quantified consumption
rates for several reported prey items. After noting negligible consumption rates on all species of macrophytes,
we conducted a series of follow-up experiments which found no effect of hunger, but a significant effect of
epiphytic communities on Patiria's consumption of macrophytes. Finally, we compared Patiria's isotopic
niche with that of giant sea stars (Pisaster giganteus), purple sea urchins (Strongylocentrotus purpuratus),
and warty sea cucumbers (Parastichopus parvimensis) and found that Patiria occupied the highest relative
trophic level, had relatively low trophic diversity, and was isotopically most similar to Pisaster (a carnivorous
species). Altogether, these results suggest that Patiria has a more limited, carnivorous diet than previously
expected, and may be able to partially fill the niches left by other sea star species.

USING STATE-SPACE MODELS TO REDUCE THE SENSITIVITY OF FISHERY ASSESS-
MENTS TO HYPOXIA (YOUTUBE)
† McLeod, MJ*; White, JW; Chan, F
Oregon Sate University

In recent years, there has been an increase in episodic coastal hypoxia along the mid to inner-shelf waters
off the Oregon Coast. Wind-driven coastal upwelling events can exacerbate the magnitude of these hypoxic
events, causing extremely hypoxic bottom water to move onshore towards the inner shelf. These events have
the potential to impact the spatial and temporal distributions of nearshore species. Fishery-independent
trawl surveys along the PNW have reported low fish catch for a variety of demersal species overlapping with
hypoxic events. These absences could reflect a behavioral response to severe hypoxia that drives species
displacement, or hypoxic events may be affecting mortality rates on nearshore species. This uncertainty
impacts the ability of fishery managers to accurately assess stock levels in a changing climate. We used
state-space population models fitted to fishery-independent datasets to quantify how hypoxia affects the
detectability of nearshore groundfish. The model structure is a state-space integral projection model that
uses a Markov Chain Monte Carlo algorithm to estimate model parameters. The key novelty is including
a parameter describing the probability of non-detection of fish as a function of Dissolved Oxygen (DO)
measured during the trawl. Analysis of simulated data have shown that the model is able to reliably
estimate that non-detection parameter. Our approach could be exported to more complex stock assessment
methods to provide more robust assessments of shelf-dwelling groundfish in the face of increasingly frequent
hypoxic ocean conditions.

Session 7: Ecosystem Assessment

* indicates presenting author, † indicates eligibility for Best Student Paper Award
CAN COASTAL WETLANDS RISE TO THE CHALLENGE? RESILIENCE OF ESTUARINE HABITATS AND CARBON ACCUMULATION TO SEA-LEVEL RISE (YOUTUBE)
Moritsch, M.M.1; K. Byrd; A. Good; M. Davis; J.Z. Drexler; I. Woo; J.T. Morris; L. Windham-Myers; G. Nakai; E. Grossman; K.L. Poppe; J. Rybczyk
1- USGS Western Geographic Science Center 2- USGS Science and Decisions Center 3- USGS Oregon Cooperative Fish and Wildlife Research Unit 4- USGS California Water Science Center 5- USGS Western Ecological Research Center 6- University of South Carolina, Department of Biological Sciences 7- USGS Water Mission Area 8- Billy Frank Jr. Nisqually National Wildlife Refuge 9- USGS Pacific Coastal and Marine Science Center 10- Western Washington University, Department of Environmental Sciences

Sea-level rise (SLR), coastal development, and obstructions to sediment delivery pose challenges to the persistence of estuarine habitats and the services they provide. Climate adaptation planning for estuaries explores sediment management actions as options for improving vertical accretion and lateral migration of tidal forests and marshes. We used a process-based soil accretion model (Marsh Equilibrium Model) combined with a habitat classification model (MOSAICS) to estimate elevation- and salinity-driven habitat shifts in a macrotidal estuary in the U.S. Puget Sound for five SLR scenarios and three suspended sediment scenarios from 2011 to 2110. We also estimated soil carbon accumulation (“blue carbon”) in the estuary. For the baseline sediment scenario, we projected that most high marsh would remain with < 100 cm SLR, but substantial area would convert to transitional marsh after 80 years with 100 cm SLR. The area of tidal forest that converts to freshwater or brackish marsh would also increase with SLR. Total carbon accumulation would accelerate over time. Doubling or tripling of suspended sediment resulted in persistence of high marsh. This pattern corresponded with carbon accumulation increases of 22 to 43%. Our results add to the body of knowledge on marsh wetland change by adding estimates of soil carbon accumulation and including feedbacks between SLR, salinity, elevation, and habitat types. We demonstrate that SLR can enhance ecosystem services despite habitat shifts.

PUTTING THE PACIFIC MARINE HEAT WAVE INTO PERSPECTIVE: RESPONSE OF LARVAL FISH OFF SOUTHERN CALIFORNIA TO UNPRECEDEDNT WARMING (YOUTUBE)
Thompson, A.R.1; Ben-Aderet, N.; Bowlin, N.; Kacev, D.; Swalethorp, R.; Watson, W
1- NOAA/SWFSC 2- State of California Ocean Protection Council 3- Scripps Institution of Oceanography

The Northeast Pacific Marine Heatwave (MHW) from 2014-2016 induced the warmest 3-year period on record in the California Current Ecosystem (CCE). We tested whether larval fish assemblage structure, phenology and diversity dynamics were comparable to past warming events from 1951-2013. First, we hypothesized, based on past observations of biological effect of warming, that mesopelagic species with southern distributions relative to southern California and Pacific sardine Sardinops sagax (a coastal pelagic species) would increase during the MHW while northern mesopelagics and northern anchovy Engraulis mordax (coastal pelagic) abundances would decline. Similar to past warming, southern mesopelagics increased and northern mesopelagics decreased. Unexpectedly, however, several southern mesopelagic taxa had record-high abundances during the MHW. Further, whereas sardine abundance did not increase, anchovy abundance rose to near-record highs in summer 2016. Second, we hypothesized that fishes would spawn earlier during the MHW. Fishes did not spawn in an earlier season within a year, but five of six southern mesopelagic taxa spawned earlier than typical within winters and springs. Third, we predicted that species richness would increase moderately due to an influx of southern and exodus of northern species. Richness, however, was the highest ever during the MHW as both southern and northern species were common. Altogether, the larval fish assemblage differed from all past years during the 2014-2016 MHW in the CCE.

The spatial and temporal variability of Haida Gwaii kelp forests (YOUTUBE)
† Gendall, Lianna1; Hessing-Lewis, Margot; Reshitnyk, Luba; Schroeder, Sarah; Costa, Maycira
1- University of Victoria 2- The Hakai Institute 3- The Hakai Institute

Kelps are dominant habitat forming organisms in nearshore temperate ecosystems that provide shelter and food for many species. Although, some areas of British Columbia have been mapped, more research is needed to establish large-scale baselines, necessary for detecting change. High-resolution satellites provide
ideal data for quantifying the distribution of kelp forests over large areas. Our goal is to develop and apply a framework for using archived satellite imagery to quantify the distribution and variability of Haida Gwaii (HG) kelp forests and understand drivers of change. The kelp forests of HG are areas of ecological value that support numerous species, cultural practices, and fisheries. However, long-term kelp monitoring in HG is at its inception and drivers are poorly understood. In order to accomplish our goal: 1) the changes in kelp distribution were assessed using high to medium resolution satellite imagery (1973-2021), and historic data, from British nautical charts (1856-1958), and 2) the trends in kelp forests persistence were compared to numerous variables to understand the relationship between kelp forests and drivers of change. Results indicate a dramatic loss of kelp from the northern portion of the study region in the late 1970s. However, when comparing this loss to multiple drivers the specific role and importance each played remains difficult to disentangle. Moreover, another large decline occurred during the 2014-2016 marine heatwave. However, kelp forests have rebounded in recent years to pre heatwave distribution suggesting resilience in this area.

ROARING 20'S: WHAT IS INCREASED BULL KELP DENSITY BRINGING TO CALIFORNIA'S NORTH COAST (YOUTUBE)
Moitoza, F.D.†; Craig, S.F.; Tissot, B.N.

Humboldt State University

Extreme environmental change has impacted the health of northern California kelp forests due to a rapid succession of catastrophic events. The loss of the predatory sunflower star to SSWD, coupled with thermal stress have shifted some of these communities from kelp forests to large scale urchin barrens, causing growing concern and grabbing mainstream media attention. The recent presence of favorable oceanographic conditions promoted successful bull kelp recruitment and maturation, creating some of the largest kelp beds in almost a decade. Although it is too early to say if this recovery will continue, or become permanent, the potential return of this ecosystem has huge implications. Here we will look at changes seen in urchin populations, kelp & invertebrate biodiversity, and fish assemblages over an 8-year time span (from 2014 to 2021) in Northern California inside as part of subtidal MPA monitoring. Differences in community composition among sites may reflect differences in urchin population dynamics, as well as provide an opportunity to assess the importance of abiotic differences across rocky reef communities on California’s north coast.

LOCAL ECOLOGICAL KNOWLEDGE AND THE HISTORICAL CONTEXT OF MARINE APEX PREDATORS NEAR ISLAS MARÍAS, MÉXICO (YOUTUBE)
† Shaff, J. F.1*; Santiago, A. M.; Aceves Bueno, E.

1- School of Marine and Environmental Affairs, University of Washington, Seattle, WA 2- Pelagios Kakunjá, La Paz, Baja California Sur, México

Islas Marías is a four-island archipelago located in the Central Mexican Pacific. Despite declarations of a Biosphere Reserve (2003) and UNESCO world heritage site (2007) for the high levels of biodiversity and endemism, the Federal Penitentiary of Mexico on Isla María Madre prevented the regular compilation of ecological data on and around the archipelago for decades until its relocation to mainland Mexico in 2019. There has been both recent and historical evidence of shark fishing around the archipelago, and a 2019 expedition found little presence of sharks around the island chain. We conducted a local ecological knowledge survey in Nayarit, Mexico with small-scale fishers to assess the historical context of marine predators in the Islas Marías archipelago. Semi-structured interviews with fishers provided insights on historical changes in shark diversity, abundance and distribution, and changes in fishing activity near Islas Marías. Most shark fishers have described increased difficulty finding sharks and declines in catches. Fishers from La Cruz de Huanacaxtle, Nayarit attribute perceived declines in shark abundance to the increased effort of large industrial fishing vessels and the use of non-selective fishing gear. As the archipelago begins to open for tourism in 2021, the fishers expressed concerns and preferred solutions for their future fishing near the islands and the continued interactions between the small-scale fisheries, the commercial fisheries, and the tourist sector in the Central Mexican Pacific.

Kelp forest trophic networks: Peer-reviewed vs. Local Ecological Knowledge (YOUTUBE)
† Vilalta, Ainoa1*; Beas-Luna, Rodrigo; Zetina-Rejón, Manuel; López-Ibarra, Gladis; Rocha-Tejeda, Lorena; Flores-Guzmán, Alesa; López-Ercilla, Inés; Rodríguez-Rodríguez, Ellmi; Sandoval-Jiménez, Sergio
Ecological Network models are valuable tools for understanding changes in the structure and function of complex marine coastal ecosystems. We developed and compared two trophic network models representing a temperate ecosystem to simulate bottom-up and top-down stressors. First, we developed a Peer-Reviewed Information Network (PRI), parameterized with in-situ observations and scientific literature. Secondly, we developed a Local Ecological Knowledge network (LEK) based on interviews with local fishers. With both models, we analyze how they compare using a diverse set of network properties and; how they behave under contrasting stressors. LEK had 52 while PRI had 40 nodes with 267 and 297 connections, respectively. We found 38% of the species in the LEK network were comprised of predators, while only 25% were predators in the PRI network. Contrary, LEK network primary producers only represented 9.6% of the species, while the PRI network was made up of 20%. Additionally, we found interesting patterns of response. With a top-down disturbance, the abundance of the groups increases alternately, whereas, in the bottom-up disturbance, changes do not transfer uniformly. Our findings highlighted the potential of model complementarity for the different sources of information and support the value of using citizen science in developing ecological network models to navigate climate-driven uncertainty or management scenarios.

Session 8: Evolutionary Biology

* indicates presenting author, † indicates eligibility for Best Student Paper Award

TRAINING MARINE SCIENCE UNDERGRADUATES TO CONDUCT GENOMICS RESEARCH, A CASE STUDY (YOUTUBE)

Caplins, Serena*; Armstrong, Madison; Grosberg, Rick; Bay, Rachael

University of California, Davis

Modern evolutionary genomics relies on the manipulation of increasingly large datasets necessitating training in computer programming. The utility of computational training is not always clear to marine science majors and opportunities for training in computer science are often inequitable. Ideally, in-class training can be coupled with applied skill development through analyses of novel data in a real research setting. We developed a course called “Marine Genomics”, which trains students with no prior coding experience to code in both bash/UNIX and R with a focused application on analyzing population genomic data of marine organisms. We paired this course with a paid summer research experience for several of the students to analyze novel population genomic data from an iconic California coastal species, the purple sea urchin. Students reported an increase in their confidence in both R and UNIX at the end of the course, and were able to actively demonstrate an increase in their coding competence in our end of course survey. The materials for the course are all hosted online and freely available to the marine and evolutionary biology community in both a 10-week quarter format and 15-week semester format. We discuss the success of this program and the further application of in-class training paired with research experiences.

MOLECULAR ANALYSIS REVEALS AN ENDEMIC LAND SNAIL LINEAGE RESTRICTED TO CALIFORNIA’S CENTRAL COAST (YOUTUBE)

Eernisse, D.J.; Gilbertson, L.H.; Goodward, D.; Vendetti, J.E.

1- Cal State Fullerton 2- Natural History Museum of Los Angeles County 3- Grand Terrace, CA

Our ongoing studies of native western North American shoulderband land snails (Helminthoglyptinae Pilsbry, 1939) have revealed that those conventionally identified as Helminthoglypta umbilicata (Pilsbry, 1898) are a surprisingly distinct lineage endemic to Monterey and San Luis Obispo counties on California’s Central Coast. Our phylogenetic analysis of combined mitochondrial and nuclear gene regions has revealed that “H.” umbilicata has only distant affinities to the more southern type species of Helminthoglypta Ancey, 1887, H. tudiculata (A. Binney, 1843), whose type locality is in southern California. Our analysis is inclusive of the diversity of shoulderband snail species from throughout the subfamily’s distribution. We have considered our results as they relate to conventional diagnoses based on shell and reproductive anatomical features. This has led us to discover that the currently accepted taxonomic placement of these land snails needs revision because otherwise the genus is polyphyletic. The Central Coast lineage is but one of multiple “Helminthoglypta” lineages whose generic placement needs revision to reflect our phylogenetic results, impacting over 100
species currently assigned to the subfamily. The ecological role of these native species is still poorly studied within western North American terrestrial ecosystems. They are subject to increasing anthropogenic threats including urbanization and expansion of non-native land snail populations.

SIZE-NUMBER TRADEOFFS AND THE COSTS OF PRODUCING LARGER OFFSPRING: A CASE STUDY OF CALIFORNIA GRUNION (YOUTUBE)

Johnson, D.W.*; Chhor, J.T.; Shelley, C.E.; Siegfried, E.J.

California State University, Long Beach

Classic theory describing the evolution of offspring size begins with the premise that there is a tradeoff between offspring size and offspring number. When a finite amount of reproductive energy is divided among offspring, a doubling of offspring size should reduce fecundity by a half. However, this inverse relationship assumes that the overall cost per unit volume is the same for large and small offspring. We tested this assumption by studying reproduction in California Grunion (*Leuresthes tenuis*). We measured fecundity and egg size for over 200 fish and found that in contrast to foundational theory, a doubling of egg volume reduced fecundity by almost a factor of 4. These results indicate that larger offspring are much more costly to produce. To understand why this might be, we measured the energy content of eggs but found that energy per unit volume was not related to egg volume. We did, however, find that mothers that produce large eggs produce more ovarian fluid per egg. Mothers that produce larger eggs thus incur ancillary costs in terms of both the energy required to produce more fluid, and the space within the body that is taken up by fluid, rather than eggs. Such ancillary effects likely play an important role in moderating the tradeoffs between offspring size and number and should be incorporated in theory describing offspring size evolution.

ECO-EVO FEEDBACKS ALTER THE EFFECTS THE COMPETITORS AND MUTUALISTS ON INVASION SUCCESS (YOUTUBE)

† Hoffbeck, C.*; terHorst, C.P.

California State University, Northridge

Invasive species are an increasing threat to ecosystems. Biotic interactions, such as competition or mutualism, can affect invasion success, but these ecological interactions can also drive natural selection and evolution during the invasion process. We used a mathematical model to examine the effects of eco-evolutionary dynamics between trait changes and mutualists to determine how they influence success and consequences of the competition between an invasive and native species. We predicted that an invasive species, new to an ecosystem and without the coevolution to defend against cheating, could destabilize the relationship between a native species and its mutualists. Our findings showed that the degree of benefit conferred on the native and invasive species from their mutualists was greatly important to the outcome of the competition between these two species, and that invasive species with stricter sanctioning against cheaters could fail to establish in an ecosystem. Further, we found that even one of the two species being lenient with sanctioning would allow cheating to rise to dominance in the mutualism, negatively impacting both the native and invasive species populations. This confirmed our hypothesis that an invasive species could indirectly impact the quality of the mutualism for a native species, furthering the consequences of invasion beyond competition between species and emphasizing the need for more research into the eco-evolutionary dynamics of invasion.

MACROEVOLUTIONARY PATTERNS IN MARINE HERMAPHRODITISM (YOUTUBE)

† Jarvis, G.C.*; Marshall, D.J.

Monash University, Centre for Geometric Biology

Most plants and many animals are hermaphroditic; it is unknown whether the same forces are responsible for hermaphroditism in both groups. The well-established drivers of hermaphroditism in plants (e.g., seed dispersal potential, pollination mode) have clear analogues in animals (e.g., larval dispersal potential, fertilization mode), allowing us to test the generality of the proposed drivers of hermaphroditism between both groups. Here, we show theories developed in plants successfully predict some patterns of hermaphroditism in marine invertebrates. Species with either internal fertilization, restricted offspring dispersal, or small body sizes are more likely to be hermaphroditic than species that are external fertilizers, planktonic developers, or larger. Plants and animals show different biogeographical patterns however: animals are less likely to be
hermaphroditic at higher latitudes – the opposite trend to that in plants. Overall, our results indicate that
similar forces, namely competition amongst offspring or gametes, drive the evolution of hermaphroditism
across the tree of life.

GENETIC CONSEQUENCES OF RANGE SHIFTS IN MARINE ENVIRONMENTS
(YOUTUBE)
† Lee, A.*; Christie, M.R.

*Purdue University

Shifting climate patterns create new selective pressures that organisms must respond to, or they will face
population declines and/or extinction. As a response to these selective pressures, marine species have
shifted, contracted, or expanded their biogeographical ranges. These range shifts can potentially change
community structure and impact the ecology and evolution of marine ecosystems. Though shifts in species’
ranges are well documented as a consequence of recent warming, their effects on species’ gene pools are
comparatively understudied. Genetic diversity influences the ability of a population to respond to selection.
High levels of standing genetic variation may help populations survive climate change and its ecological
effects. Conversely, populations with low genetic diversity may have a limited capacity to respond to selection
imposed by environmental perturbations. As species shift their biogeographical ranges to track warming sea
temperatures, range expansions and contractions will also affect a species’ overall genetic diversity. Here, I
synthesize the literature on the current paradigm of range shifts for the genetics of populations, then examine
empirical studies in marine ecosystems in the context of this paradigm, and finally propose a new framework
for marine range shifts and their genetic consequences.

DRIVERS OF SPERM METABOLISM AMONG- AND WITHIN SPECIES
† Potter, A.E.*; Marshall, D.J.

*Monash University

Sperm face the singular, formidable task of successfully fertilising an egg, but they have finite energy reserves,
and a limited lifespan. The trade-off between sperm metabolism and longevity imposes strong selection to
optimise energy allocation but the drivers of sperm metabolism remain poorly resolved. While our under-
standing of metabolism more generally has increased enormously, our understanding of sperm metabolism
is quite limited. Among sperm, we believe that three key factors that are likely to affect sperm metabolism;
temperature, size, and density. Here, we compiled all of the available data on sperm metabolism to estimate
how sperm metabolic rate changes with temperature, size and sperm concentration both within- and
among-species. Sperm from higher temperatures have higher metabolic rates, but sperm metabolism is less
affected by temperature than would be expected based on general rules regarding the temperature depen-
dence of metabolism. We find countergradient variation in sperm midpiece size with temperature, whereby
sperm in warmer conditions are smaller overall and have smaller midpieces, which may partially offset the
effects of temperatures on metabolic rate. Sperm exhibit density-dependent metabolism, both among- and
within-species whereby sperm experience metabolic suppression at high densities, however this relationship
is shallower than estimate from unicellular organisms. Together, our results reveal sperm metabolism is
relatively robust to temperature variation and local competitive environments (density), within- and among-
species.

Session 9: Conservation and Restoration / Anthropogenic pollution in marine
environments
* indicates presenting author, † indicates eligibility for Best Student Paper Award

EVALUATING STAKEHOLDER PERCEPTIONS OF MICROPLASTICS MANAGEMENT
IN OREGON
† Hurst-Mayr, M.A.*

*Portland State University

Microplastics (MP) are an emerging contaminant in marine ecosystems, water resources, and seafood that
lack widespread standardized measurement or regulation in the United States. Concern has grown not only for the effect of microplastics on the environment, but also for the potential to affect human health. The presence of microplastics in food and water supplies requires management action. California has established policy to measure and manage the quantity of MP in state waters. However, Oregon lacks such management structure. As a coastal state with many marine resources and interests, Oregon will likely face increasing pressure to set measurement standards to quantify microplastics contaminating waterways and possible source reduction. Understanding the priorities of the major groups involved in microplastic issues in Oregon is essential to providing a state-wide solution to limit source output of MPs. Major players in MP pollution may include state agencies, non-profit organizations, the fishing industry, and any other groups whose well-being is impacted by water quality. Using surveys, this study evaluated baseline attitudes towards microplastics management and identified the priorities, concerns, and barriers to controlling MP pollution in Oregon. Discerning what challenges and data gaps there are to addressing pollution reduction will inform future endeavors to manage MP in Oregon waterways.

**Variation in Coral Thermotolerance Across a Pollution Gradient Erodes as Coral Symbionts Shift to More Heat-Tolerant Genera**
† Naugle, M. S.1*; Oliver, T. O.; Barshis, D. J.; Gates, R. D.; Logan, C. A.

1- California State University, Monterey Bay, Department of Marine Science, Seaside, CA, USA 2- NOAA Pacific Island Fisheries Science Center, Honolulu, HI 3- Old Dominion University, Department of Biological Sciences, Norfolk, VA, USA 4- Hawai‘i Institute of Marine Biology, University of Hawai‘i at Mānoa, Kāne‘ohe, HI, USA

Phenotypic plasticity is one mechanism whereby species may cope with environmental stress. Reef building corals present a good model for studying plasticity as they have experienced rapid climate-driven declines, often with differential survival among individuals during heat stress. Variation in thermotolerance may be driven by differences in baseline levels of environmental stress, including pollution stress. To examine this possibility, acute heat stress experiments were conducted on Acropora hyacinthus from ten sites around Tutuila, American Samoa with differing nutrient pollution impact. A threshold-based heat stress assay was conducted in 2014 and a ramp-hold assay was conducted in 2019. Bleaching responses were measured by assessing color paling. qPCR was used to measure endosymbiont community at each site. RNAseq was used to compare coral gene expression prior to heat stress in 2019. In 2014, polluted sites held more thermotolerant corals and higher proportions of heat tolerant Durusdinium. By 2019, thermotolerance exhibited no clear trend by pollution level. This coincided with a shift towards Durusdinium across all sites, reducing symbiont community differences seen in 2014. While pollution and symbiont community no longer explained variation in thermotolerance by 2019, baseline gene expression could predict thermotolerance thresholds. This study documents a shift in symbiont community over time and highlights how gene expression patterns may aid in identifying heat-tolerant corals in a future where symbiont-driven thermotolerance has reached an upper limit.

**PRE-FERTILIZATION EXPOSURE OF GAMETES TO MICROPLASTICS CAUSES DEVELOPMENTAL ABNORMALITY IN STRONGYLOCENTROTUS PURPURATUS EMBRYOS**
† Sarin, A. L.*; Adams, N. L.

*Cal Poly SLO*

Growing awareness of microplastics has catalyzed increased interest in effects of microplastics on marine organisms. Using *Strongylocentrotus purpuratus* as a model organism, we examine effects of pre-fertilization exposure of gametes to microplastics on fertilization and development. We exposed sea urchin gametes to low (0.1 mg/L) or high (1.0 mg/L) concentrations of either polymethyl methacrylate (PMMA) or polyethylene (PE). Gametes were combined in the following combinations: exposed eggs + exposed sperm; exposed eggs + non-exposed sperm or non-exposed eggs + non-exposed sperm. Effects of gamete exposure to microplastics were isolated based on gamete, concentration, and plastic type. Exposure of gametes to either microplastic caused no significant differences in fertilization success or early development (24 hrs after fertilization). Embryos from eggs exposed to high concentrations of PE had significantly more developmental abnormalities than the control embryos 48 hours after fertilization (*p = 0.003*). Furthermore, after 48 hours, embryos
from eggs exposed to higher levels of PE had significantly higher rates of developmental abnormality than those from eggs exposed to lower concentrations of PE (p = 0.031). Embryos exposed to PMMA showed no significant differences from the controls over the first 48 hours of development. These data indicate that microplastic exposure can cause a deleterious effect on the development of purple sea urchins.

**THE SILENCE OF THE CLAMS: FORESTRY REGISTERED PESTICIDES AS MULTIPLE STRESSORS ON ADULT SOFT-SHELL CLAMS**

† Tissot, A.G.; Granek, E.F.; Thompson, A.W.; Hladik, M.L.; Moran, P.W.; Scully-Engelmeyer, K.

1- Portland State University 2- USGS, Sacramento CA 3- USGS, Tacoma WA

The US forestry industry commonly applies multiple pesticides to control plant and insect pests. A recent study confirmed the presence of such pesticides in water and bivalves sampled in Oregon coastal watersheds and estuaries. Though previous studies have determined individual organism effects of these compounds, sub-lethal effects of environmentally relevant concentrations of these chemicals in combination have not been tested. We conducted a 90-day laboratory experiment examining the effects of four forestry registered pesticides: Atrazine, Hexazinone, Indaziflam, and Bifenthrin, on the soft-shell clam *Mya arenaria*, a common estuarine species. Growth, feeding rate, and condition index were measured, and mortality was recorded. Individually and in combination with other pesticides, Indaziflam and Atrazine exposure resulted in the highest mortality rates (9-36% and 18-27%, respectively). Indaziflam concentrations in tissue were higher than those of atrazine, despite equal dosing concentrations. Clams exposed to indaziflam and hexazinone experienced reduced condition index and clearance rates individually and in combination with other compounds, however the two combined had an antagonistic relationship. At environmentally relevant concentrations, these compounds affect fitness and survival of a non-target estuarine bivalve and, the herbicide indaziflam both accumulated in clam tissue and was more toxic than other tested pesticides. These findings highlight the need to both further study and regulate multiple compound exposure to address impacts on ecosystems.

**SEVERE INTRODUCED PREDATOR IMPACTS DESPITE ATTEMPTED FUNCTIONAL ERADICATION**

Blumenthal, Jeffrey G.; Brian S. Cheng; Andrew L. Chang; Jordanna Barley; Matthew C. Ferner; Karina J. Nielsen; Gregory M. Ruiz; Chela J. Zabin

1- Smithsonian Environmental Research Center; Estuary and Ocean Science Center, San Francisco State University 2- Department of Environmental Conservation, University of Massachusetts Amherst; Smithsonian Environmental Research Center 3- Smithsonian Environmental Research Center 4- Department of Environmental Conservation, University of Massachusetts Amherst 5- San Francisco Bay National Estuarine Research Reserve 6- Estuary and Ocean Science Center, San Francisco State University

Established non-native species can have significant impacts on native biodiversity without any possibility of complete eradication. In such cases, one management approach is functional eradication, the reduction of introduced species density below levels that cause unacceptable effects on the native community. Here, we evaluate the potential for functional eradication of introduced predatory oyster drills (*Urosalpinx cinerea*) using a community science approach in San Francisco Bay. We combined observational surveys, targeted removals, and a caging experiment to evaluate the effectiveness of this approach in mitigating the mortality of prey Olympia oysters (*Ostrea lurida*), a conservation and restoration priority species. Despite the efforts of over 300 volunteers who removed over 30,000 oyster drills, we report limited success and discuss several possible mechanisms for this result with broad relevance to management for this and other introduced species. At two removal sites, there was no effect of oyster drill removal on oyster survival, tested with caging experiments (0 and 1.6% survival in open and partial cage treatments, as compared to 89.1% in predator exclusion treatments). We conclude that functional eradication of this species requires significantly greater effort and may not be a viable management strategy. Sites without *Urosalpinx* should be prioritized for restoration.

**THE MPA GUIDE: A NEWLY PUBLISHED FRAMEWORK TO CATEGORIZE, EVALUATE, AND PLAN MARINE PROTECTED AREAS**

Sullivan-Stack, J.; Field, L.; Grorud-Colvert, K.

*Oregon State University*
Marine protected areas (MPAs) are widely used biodiversity conservation tools that can provide benefits for both people and marine biodiversity. MPAs vary widely in both form and function, with some restricting all extractive and destructive activities while others are impacted by a variety of human activities and types of resource extraction. This range of protection levels can lead to confusion regarding what outcomes can be expected from a given MPA. To improve clarity around MPAs, a new science-based, policy-relevant MPA evaluation framework, The MPA Guide, was developed through a multi-year, highly collaborative international process. This presentation will share the four core elements of the Guide: (1) Stage of Establishment, which specifies the current status of an MPA in its progression towards being Actively Managed and most effective; (2) Level of Protection, which describes protection of biodiversity and habitats from impacts of abatable human extractive or destructive activities; (3) Enabling Conditions, or the important social and ecological considerations that are prerequisites for effective and equitable MPAs; and (4) Outcomes that can be expected from an MPA at a given Stage and Level, if Enabling Conditions are met. We will share examples from an ongoing MPA Guide assessment in the United States, and discuss implications and future directions of this work.

**USING AN ELEVATION PORTFOLIO APPROACH FOR SUCCESS IN PASSIVE RESTORATION OF NATIVE OYSTERS IN SAN FRANCISCO BAY** *(YOUTUBE)*

Zabin, C.Z.¹; Ayala, G.S.; Kiriakopolos, S.; Blumenthal, J.G.; Grosholz, E.D.

1- Smithsonian Environmental Research Center 2- San Francisco State University 3- University of California, Davis

Passive habitat restoration that depends on natural dispersal of a target species to project sites is reliant on two major sets of processes: those that influence the quantity and timing of the arrival of propagules and those that affect survival and growth post recruitment. Particularly relevant for passive restoration projects is an understanding of the relative importance of rate of propagule arrival vs. post-settlement survival, as the same location might not be ideal for both sets of processes, but these data are often unavailable. Restoration projects are often not monitored more than one year post-construction, with the result that predictors of longer-term success may not be clear. We monitored native oysters (Ostrea lurida) that naturally recruited to restoration substrates for five years at two sites in San Francisco Bay. We report on changing rates of recruitment and adult densities over time that show different trajectories at different locations. We document gradients in predation, competition, and physical stress along a short elevation span that correspond with differences in adult densities. These results demonstrate that for restoration to be successful over these gradients as well as with interannual and site-specific variability, it is critical to take a portfolio approach that involves using a range of sites and tidal elevations to ensure success at the end of the project. Additionally, our longer-term dataset demonstrates the differences in conclusions we might have drawn from short-term monitoring (<2 years) compared with the full 5 years.

**PARTIAL TO PURPS: POST-SETTLEMENT SUNFLOWER STAR JUVENILES FARE BEST ON A DIET OF PURPLE URCHINS** *(YOUTUBE)*

Brito, Michael*; Anteau, Fleur; Hodin, Jason

Friday Harbor Labs

In 2013, sea star populations throughout the NE Pacific fell dramatically due to an unprecedented outbreak of sea star wasting (SSW) syndrome. The sunflower sea star, *Pycnopodia helianthoides*, appeared to suffer the heaviest losses, which resulted in its listing as critically endangered by the International Union for the Conservation of Nature. This is a particular cause for concern since the sunflower sea star is suspected of having a vital function in maintaining healthy kelp forest ecosystems. Our captive rearing project at Friday Harbor Labs aims to understand the husbandry conditions needed for optimal juvenile growth. This includes finding the best diet for the early juvenile stages (0.5-1 mm diameter), which we have identified as a key stage with the highest potential for mortality. In an effort to understand this species’ life history and optimize rearing strategies, we conducted experiments testing various food items on *P. helianthoides* juveniles and monitored their growth and consumption rates. Our preliminary findings suggest that a diet consisting of purple urchin juveniles ( *Strongylocentrotus purpuratus* ) yields the highest average growth and lowest percent mortality among a variety of tested diets. Our findings for the first time suggest that sunflower stars may exert top-down predatory control on purple urchins throughout both species’ post-settlement stages,
and might help to explain the apparent rapid phase shifts from bull kelp-dominated to urchin-dominated habitats in large areas of the NE Pacific following the recent SSW pandemic.

**THE KIDS ARE NOT ALL RIGHT: RESPONSES OF JUVENILE PURPLE SEA URCHINS TO JUVENILE SUNFLOWER SEA STARS (YOUTUBE)**

Anteau, F.P*; Brito, M; Hodin, J  
University of Washington

Within the kelp forest ecosystems of the NE Pacific coast, population decreases in the predatory sunflower star, *Pycnopodia helianthoides*, have coincided with increases in purple urchins, *Strongylocentrotus purpuratus*. Subsequently, bull kelp, *Nereocystis luetkeana*, have dramatically decreased. Characterizing sunflower sea stars’ predator-prey interactions with purple urchins could illuminate the causative factors in kelp disappearance and indicate ways to facilitate the recovery of these ecosystems. Previous studies have explored the interactions between the adult stages of both of these species, and the literature describing their interactions is growing rapidly. This includes studies testing escape responses in the prey in response to the presence of the predator. Here, we examined parallel interactions at the early juvenile stages for the first time, conducted as part of a P. helianthoides captive rearing program at Friday Harbor Labs in the Salish Sea. Specifically, we will report our interim findings of ongoing experiments to assess responses in juvenile purple urchins (0.25-2 mm diameter) to the presence of juvenile sunflower sea stars (0.6-5.5 mm diameter). We will discuss the importance of considering the entire benthic life history of both predators and their prey in understanding the functioning and disruption of complex ecosystems such as kelp forests.

**APPLYING THE MPA GUIDE STAGE OF ESTABLISHMENT AND LEVEL OF PROTECTION TO REAL-WORLD MPAS (YOUTUBE)**

† Field, L.C*; Sullivan-Stack, J; Grorud-Colvert, K  
Oregon State University

A newly published marine protected area (MPA) evaluation framework, *The MPA Guide*, helps provide a clear understanding of what “protection” really means and what outcomes may be expected from a given MPA. Two key aspects of this framework are Stage of Establishment, which describes the status of an MPA in the progression towards Actively Managed, and Level of Protection, which is how protected an MPA or zone is from abatable human extractive activities. We have begun to assess MPAs around the globe to better understand the processes behind Stages and Levels, and how The Guide can be useful for planning, implementing and tracking MPAs. Here we share progress towards a better understanding of Stage and Level based on specific MPAs, the relationship between Stage and Level, and the Outcomes that can be expected when they are coupled with the social and ecological conditions essential to effective and equitable MPAs.

**MANAGED AND UNMANAGED WHALE MORTALITY IN THE CALIFORNIA CURRENT ECOSYSTEM**

1- UC-Davis 2- UC - Davis 3- California Polytechnic State University 4- California State University Northridge 5- California State University Monterey Bay 6- San Francisco State University 7- Oregon State University

Whales serve important biological and cultural functions in the California Current Ecosystem (CCE). Due to elevated mortality rates related to ship strike and entanglement in recent years, the California Ocean Protection Council has articulated a goal to achieve zero human-driven mortality for CCE whales, with a target of creating a statewide plan by 2022. Zero mortality is a laudable but difficult goal to achieve as success depends on understanding the existing sources of mortality, opportunities for policy change, and coordination of activities across the entire CCE. We synthesize the available research on drivers of whale mortality in the CCE and existing policy that addresses those drivers. Five main threats contribute to whale mortality in the CCE and are currently targeted through relevant policy responses: entanglement, vessel strikes, noise, water quality, and marine debris. Three threats remain largely unaddressed in management, despite their contribution to lethal and sublethal impacts on whales: nutritional stress, disease, and predation. Ultimately,
sources of whale mortality are interconnected and their impacts span both geographic and jurisdictional boundaries, necessitating a holistic approach to managing whale mortality in the CCE.

**RECOMMENDATIONS FOR TURFS IN EL CORREDOR REGION OF BAJA CALIFORNIA SUR, MEXICO (YOUTUBE)**

† San, AL†; Aceves-Bueno, E; Beaudreau, A

*School of Marine and Environmental Affairs at the University of Washington*

Small-scale artisanal fisheries provide millions of people in developing countries with food and employment. Though there is some oversight of small-scale fisheries by local governments, there is little data about their respective fish stocks and fishery patterns to inform thorough management decisions. Despite this, there is a number of management strategies employed to ensure the sustainability of marine resources targeted by small-scale fisheries. One strategy is the use of territorial-use rights in fisheries (TURFs), which are an area-based resource management strategy rather than quota-based. They can be combined with no-take reserves to form TURF-reserves and aim to give members of local fishing communities the power to manage their resources. We looked to small-scale artisanal fisheries in El Corredor region of Baja California Sur, Mexico as a case study to develop recommendations for TURF and TURF-reserve establishment. We constructed boundaries for TURFs and TURF-reserves based on current fishing activity reported by local fishers and habitat characteristics important for the commercially important finfish species Pacific red snapper (*Lutjanus peru*). Our results reflect the performance of different spatial arrangements of TURFs and TURF-reserves projected over 20 years based on current biological and economical values.

**PATTERNS AND CONSEQUENCES OF MICROPLASTIC POLLUTION IN DEEP-SEA HABITATS**

Smith, T.M.*

*California State University Northridge*

Due to harmful effects plastic pollutants have on marine life, it is important to understand where they may accumulate over time. National Marine Sanctuaries (NMS) protect invaluable oceanic biodiversity and are home to unique deep-sea habitats consisting of rare species, thus it is important to monitor potential threats such as microplastic pollution. The goal of this study was to identify and quantify the amount of microplastics in deep-sea habitats within Californian NMS as a function of depth and proximity to shore within the Monterey Bay, Greater Farallones, Cordell Bank, and Channel Islands NMS. Water samples were collected via Niskin bottles deployed on a remotely operated vehicle throughout the water column within each sanctuary and filtered to quantify microplastic density. Water samples were collected from depths ranging from the surface to over 3,000 meters along with hydrographic data from a CTD to determine if the quantity of microplastics changes with water mass properties of each water layer. Microplastic concentrations decreased with depth, but were seen in all collected water samples. Microplastic pollution is of particular concern to many stakeholders, however, the amount of research conducted is not reflective of the level of impact this marine debris may have on rare deep-sea ecosystems. To advance management of this problem, research is needed addressing the identity, transport, and fate of microplastics and associated contaminants.

Session 10: Fisheries Ecology / Behavioural Ecology

* indicates presenting author, † indicates eligibility for Best Student Paper Award

**FACTORS INFLUENCING AGGRESSIVE INTERACTIONS IN A CLONAL SEA ANEMONE (YOUTUBE)**

Kirk, N.L.; Mitchell, P.; Gonzalez, X.; Brar, M.; Elder, H.

1- Oregon State University 2- King Abdullah University of Science and Technology 3- University of Massachusetts 4- University of Southern California

There is competition for space in the rocky intertidal zone that can lead to aggressive interactions over this shared resource. This is exemplified in the sea anemone *Anthopleura elegantissima*, which forms clonal aggregations that aggressively defend themselves against conspecifics often resulting in injury to one or both of the combatants. Within the colony there is also division of labor with a peripherally located “warrior”
class engaging in a majority of defense protecting the larger “reproductive” class in the middle. In this study, we collected multiple individuals from 57 clones along the shoreline at 2 sites on the Oregon coast to determine if spatial position, class or genetic relatedness explained the aggressiveness and outcome of the interaction. After a brief acclimation period in the lab, anemones from different clones were moved into contact and aggression was scored. Position in the water column and distance apart had no effect on the outcome of the interaction, but size was a significant predictor with the larger individual “winning”. The class (warrior vs. reproductive) had no significant effect on the outcome, contrary to predictions possibly due to the relatively larger size of the reproductive individuals.

MOON PHASE EFFECT ON SOUND PRODUCTION OF SPAWNING GIANT SEA BASS (STEROLEPIS GIGAS) (YOUTUBE)
† Burns, E.H.; Franklin, M.P.; Allen, L.G.

California State University of Northridge

Giant Sea Bass (GSB), Stereolepis gigas, is the largest marine bony fish off the coast of California, an apex predator, and is currently classified as critically endangered by IUCN Red List. Despite recent studies on GSB, there is no documentation of their spawning and related reproductive behaviors in their natural environment due to their depressed population size. Through preliminary data and past research, we have discovered that GSB can produce a variety of sounds (many sounding like a “boom”). Some of these sounds have been observed to be linked with antagonistic behaviors towards GSB males by other GSB males in spawning aggregations. In 2019 a specific spawning sound was observed to only be produced by males and while they spawn. Past studies have observed that the closer in proximity you are to a GSB spawning aggregation the louder and more numerous GSB sounds are heard. We believe that sound production is used for spawning and can determine when GSB reproduce. According to previous literature other marine fish spawn according to moon phase. To better capture GSB spawning events it is important to determine when GSB spawn. We hypothesize that GSB spawn in accordance to moon phase. This talk explores whether GSB to produce more or less sounds due to the effect on moon phase during spawning. This will be key in determining when GSB spawn, which will be necessary to understand their reproduction. By understanding when they spawn, we can help increase their population size and remove them the endangered species list.

CORAL FEEDING PREFERENCE OF THE HAWAIIAN CUSHION STAR (CULCITA NOVAEGUINEAE) (YOUTUBE)
† Escontrela, D.1*; Hixon, M.

1- University of Hawai‘i at Mānoa, School of Life Sciences 2- University of Hawai‘I at Mānoa, School of Life Sciences

As reefs face mounting pressures, controlling local threats, such as excess coral predation, is a key management strategy. The cushion star (Culcita novaeguineae), a coral predator, has seen an explosion in abundance since the 1980s at some sites around O‘ahu, Hawai‘i. My research seeks to understand the coral feeding preferences of cushion stars. I have deployed in situ cages where I starve cushion stars for a week and then place two species of coral with the cushion star for another week. At the end of the trial, I rank corals based on consumption preference. This novel undersea approach allows cushion stars to be exposed to their normal olfactory cues. I have thus far conducted 93 trials with 13 combinations of coral species. The cushion stars have overwhelmingly preferred Pocillopora species followed by Montipora patula and Montipora capitata. On a few occasions mounding Porites species and Porites compressa have been consumed while Lobactis scutaria has been avoided completely. This research will help coral reef managers as it will identify which coral species are suffering increased predation and how cushion star feeding may shift as different coral species decline due to coral bleaching.

EFFECTS OF FISHING DOWN PREDATORS ON SCHOOLING CORAL REEF FISH
† Guerra, A.S.1*; McCauley, D.J.; Lecchini, D.; Caselle, J.E.

1- UCSB 2- EPHE, PSL

Human-induced environmental change has affected ecosystems on a global scale, altering the behavior, ecology, and evolutionary trajectories of various species. Fishing of marine top predators and the cascading
effects this may have on marine ecosystems is of critical concern. Predators are thought to be an important reason for why fish form schools, thus, a reduction in predator populations could alter schooling behavior for prey fish. Here, we investigate the indirect effects of fishing predators on the schooling behavior of coral reef fishes. We compared the tendency to school for three fish species between two Pacific coral reefs: Palmyra Atoll (USA), an unfished reef with high predator abundance, and Moorea (French Polynesia), a fished reef with low predator abundance. We also specifically characterize movement and foraging-associated behaviors of one of these fishes, the convict surgeonfish (Acanthurus triostegus), in this same comparative context. Our work suggests that reduced predator abundance may reduce the tendency of some, but not all, fish species to form schools. Decreased predator abundance also appears to have affected movement of schooling and solitary A. triostegus, with increased movement occurring in contexts with low predator abundance. These observations shed some empirical light on how overfishing may be affecting schooling behavior in schooling fish. Such insight is of value in the context of coral reefs where shifts to behavior of lower-trophic fish could have knock-on consequences for the functioning of these vulnerable ecosystems.

Evaluating mechanisms of prey selection by a fish predator and their urchin prey linked to habitat-specific differences

† Liebergesell, M.W.*; Wetmore, L; Anderson, T.W.w

San Diego State University

Giant kelp forests are highly productive and structurally complex temperate ecosystems that play a vital role in providing important habitat for many coastal fishes and invertebrates. Recently, local and global stressors have caused the degradation of kelp forests and their subsequent shift to alternative ecosystem states known as urchin barrens. Characterized by high densities of sea urchins, the stability of the urchin barren ecosystem state is heavily reliant on factors that influence sea urchin abundance and distribution. Interactions between predators and urchin prey in these habitats is critical to understanding potential phase shift dynamics driving kelp forest loss and facilitation of barren persistence. In a series of laboratory mesocosm experiments, we evaluated how habitat-specific differences in purple urchins (Strongylocentrotus purpuratus) might mediate predator (California sheephead, Semicossyphus pulcher) selection of urchin prey. Manipulating urchin gonad condition in choice experiments, sheephead could orient towards high- and low-condition prey via potential chemical cues. Further experiments included manipulation of condition and urchin attachment strength in urchin patches to explore how sheephead may demonstrate learning behavior in prey selection. Results from our research suggest that sheephead learn from repetitive consumption events and avoid foraging in patches where they have previously experienced starved, nutritionally poor-quality urchins, which may promote barren persistence through patch selection and avoidance of undesirable prey.

MODEL APEX PREDATOR (GIANT SEA BASS) MODIFIES BEHAVIOR OF MESOPREDATORY FISHES AROUND SANTA CATALINA ISLAND, CA

† Reed, K.C.*; Steele, M.A.

California State University, Northridge

Giant sea bass (GSB), though once abundant on the nearshore rocky reefs of southern California, were fished to near extinction during the 20th century. Their populations have only started to recover recently. GSB fill a unique niche, being the only resident apex predator of California’s plentiful mesopredators, such as kelp bass, sheephead, and rock wrasse. The goal of this study was to test how GSB affect the behavior of smaller fishes. A life size model of a GSB and baited remote camera apparatus was used for this test. Baited camera trials were run with and without the GSB model attached. Mesopredator behavior around the bait was then analyzed when the model was present vs. not present. It was found that mesopredator fishes were more tentative to approach the bait and much less likely to feed when the GSB model was present. Future analysis will include whether these responses differ between present-day GSB aggregation sites and areas where GSB are still rare. In an ocean where apex predators have drastically declined, it is important to track how their re-establishment through successful conservation measures may impact the surrounding systems.

VITAMIN SEA: FECES CONSUMPTION BY HERBIVOROUS CARIBBEAN FISHES AND ITS NUTRITIONAL VALUE

Rempel, H.S.*; Siebert, A.K.; Van Wert J.C.; Bodwin, K.N.; Ruttenberg, B.I.
Parrotfishes (Labridae: Scarini) and surgeonfishes (Acanthuridae) are abundant Caribbean herbivores that primarily graze reef algae, indirectly benefiting reef-building corals that compete with algae. These nominal herbivores also graze on a diverse array of non-algal food sources, including cyanobacteria and detritus; yet, to our knowledge, coprophagy (feces consumption) by these fishes has never before been documented in the Caribbean region. Based on surveys of fish foraging behavior, we found that all three surgeonfishes and six of the nine parrotfishes surveyed consume the feces of an abundant planktivore, the Brown chromis (Chromis multilineata), though coprophagy rates varied by species. Based on surveys tracking C. multilineata feces, we found that ~85% of fecal pellets were ingested by reef fishes and >90% of ingested fecal pellets were consumed by parrotfishes and surgeonfishes alone. To assess the nutritional value of this behavior, we analyzed the composition of carbohydrates, lipids, proteins, total calories, and minor and trace elements in the feces and compared these to published values for various macroalgae, the epilithic algal matrix, and cyanobacteria. Our findings suggest that these fecal pellets may be rich in protein and total calories, as well as micronutrients, such as phosphorus, compared to various algal food sources. This study advances our understanding of the foraging ecology of these major herbivores and highlights the importance of coprophagy in nutrient recycling on coral reef ecosystems.

Experimental manipulation of crushed conspecifics rather than predator presence modifies purple sea urchin grazing behavior (YOUTUBE)

† Sheridan, C.J.1; Randell, Z.H.; Carr, M.H.

1- University of California, Santa Cruz 2- Oregon State University

Recent climatic events and subsequent community shifts in kelp forest ecosystems have drawn attention to the processes regulating sea urchin populations and urchin behavior. The switch in purple sea urchin (Stronglyocentrotus purpuratus) behavior from passive to active grazing plays a key role in these shifts in ecosystem state. Sea urchins may alter grazing behavior in response to cues such as food availability, their condition, predator presence, and the crushing of nearby urchins. While something is known about how urchins respond to each of these cues in isolation, the relative importance of each and any interactions between them are less understood. Furthermore, we need to know the ultimate effect these cues have on living kelp to better understand kelp forest to barrens shifts and what may reverse them. In a controlled caging experiment in Monterey we observed that adding crushed urchins to cages reduced the number of exposed urchins grazing on live kelp and increased kelp survival. This effect was observed with or without the presence of banded red rock crabs (Cancer productus). In our experimental setup, it took approximately 48 hours after crushing for the number of exposed grazing urchins to reach the numbers observed in cages without crushing. This suggests consistent urchin predation events may be needed to provide a lasting beneficial effect on kelp. Further investigation might consider whether urchin predators are indeed functionally redundant with respect to the behavioral effect they have on urchins by testing additional predator species.

MOMMA’S LARVA: MATERNAL INVESTMENT AND OCEANOGRAPHIC CONDITIONS INFLUENCE EARLY SURVIVAL OF ROCKFISH (YOUTUBE)

Fennie, H.W.1; Ben-Aderet, N; Kwan, G; Thompson, AR

1- NOAA SWFSC & UCSC 2- Ocean Protection Council 3- Scripps Institute of Oceanography 4- NOAA SWFSC

Larval fish mortality is incredibly high, but small changes in mortality rates can lead to large changes in recruitment. Therefore, identifying factors that affect larval mortality is critical for understanding drivers of fish population dynamics. Recent work suggests maternal provisioning can dramatically affect the susceptibility of larvae to starvation and predation, which are the two major sources of early life mortality. We employed otolith microstructure analysis to examine larval traits of 8 rockfish species (5 commercially/recreationally fished and 3 non-targeted) collected in CalCOFI surveys within the southern California Bight from 1998-2013. Otolith nuclear radius, a proxy for maternal investment, was significantly positively related to age and growth rate at time of collection. This indicates that individuals with higher maternal investment grow faster and are more likely to survive early life stages. Otolith core size correlated positively with colder
water temperature experienced by parents during the four months prior to larval collection. In addition, core size was larger further from fishing ports possibly because these locations were historically less fished and contained more older, larger females and/or had inherently better habitat quality than sites closer to shore. These results indicate that the degree of maternal investment drives early survival of rockfishes and that maternal investment is influenced by oceanographic conditions and potentially habitat characteristics or fishing risk.

INTERNATIONAL MARKET DEMAND DRIVES A SMALL-SCALE CENTRAL PACIFIC REEF SHARK FISHERY TOWARDS COLLAPSE (YOUTUBE)
Goodman, M.C.*; White, T.D.; Kazdan, J.; Micheli, F.; De Leo, G.A.

Small-scale fisheries are immensely important for the livelihoods and cultural identities of millions of people around the world. On Teraina, an Island in the central Pacific nation of Kiribati, reef sharks have been harvested for cultural and subsistence purposes for generations. Recent international demand for shark fins has provided a new source of income for fishers on Teraina and has driven increases in harvest rates, yet the fishery has remained small – comprising only 17 fishers and 8 boats at the time of study. To understand the impacts of this fishery on the grey reef shark population, we interviewed local fishers, obtaining estimates of catch per unit effort data as early as 1983 and validating these estimates with storehouse inventories. We combine these data with previously obtained estimates of demographic parameters for grey reef sharks at nearby Palmyra atoll, constructing a dynamic, hierarchical Bayesian Beverton-Holt population model for grey reef sharks on the island of Teraina. Our model suggests that, without needing to account for exogenous fishing mortality, a small number of fishers and motorized boats may have plausibly driven a population of grey reef sharks on surrounding reefs to collapse, declining by as much as 75% over 30 years. These results highlight the vulnerability of sharks and other slow-growing marine megafauna to international market demand.

DDNA METABARCODING OF DIGESTED STOMACH CONTENTS TO ASSESS DIET OF PELAGIC FISHES (LAMPRIS MEGALOPSIS AND L. INCOGNITUS) IN HAWAII (YOUTUBE)
Himmelsbach, N.S.*; Iacchei, M.J.

Bigeye (Lampris megalopsis) and smalleye (L. incognitus) opah are highly migratory predatory fishes frequently observed in the North Pacific Subtropical Gyre. Previous studies suggest that opah prey on a wide variety of fishes and cephalopods. Many of the challenges faced in prior studies, which rely on morphological identification of prey, stem from the rigor of identifying fragments of soft-bodied organisms and highly digested prey, resulting in classifying prey to family, or labeling as ‘unknown’. dDNA (diet DNA) metabarcoding of stomach contents or feces has emerged as a complementary technique that allows a greater number of prey items to be identified to species than morphological identification alone. This study illustrates how utilizing dDNA metabarcoding to complement traditional morphological identification of prey increases the number of organisms detected and identified to species. Stomachs from Lampris spp. were dissected and digested stomach contents were sequenced at the cytochrome c oxidase subunit I (COI) and 12S regions on an Illumina MiSeq. This study shows how metabarcoding can increase detection of consumed prey to species level even when an individual’s stomach contains no distinguishable prey. This study provides evidence that dDNA metabarcoding expands the diversity of prey species identified and contributes additional life history information to individuals where stomach contents are too degraded for morphological identification of prey species.

MODELING THE IMPACT OF HABITAT AND FISHING HETEROGENEITY ON THE PERFORMANCE OF A TAC-REGULATED FISHERY
Pourtois, J.*; Provost, M.; Micheli, F.; De Leo, G.

Fisheries are often characterized by high heterogeneity in the spatial distribution of habitat quality, as well
as fishing effort. However, in several fisheries, the objective of achieving a sustainable yield is addressed by limiting Total Allowable Catch (TAC), set as a fraction of the overall population, regardless of the spatial distribution of fish and fishing effort. Here, we use an integral projection model to investigate how stock abundance and catch in an overcapitalized TAC-regulated fishery are affected by the interaction of heterogeneity in habitat quality and fishing effort. We parametrized the model with reference to abalones—a species characterized by limited dispersal at the larval phase and by the Allee effect. We found that a homogeneous fishing pressure in a spatially heterogeneous fishery leads to the under-exploitation of high-quality areas. However, this leads to different fishery outcomes depending on the stock’s exploitation status, namely: sub-optimal exploitation, when the TAC is set so that to achieve the maximum sustainable yield, and stability when the fishery is overexploited. Concentration of fishing effort in productive areas can compensate for this effect, which, similarly, has opposite consequences in both scenarios: fishery performance increases if the TAC is sustainable but decreases in overexploited fisheries.

Effects of Depth and Kelp Resources on Urchin Roe Quality, Morphology and Diet (YOUTUBE)
† Caley, A.J.; Vergès, A.; Marzinelli, E.; Byrne, M.

1- University of New South Wales 2- University of Sydney

Kelp forests are important temperate marine habitats that support biodiversity and sustain commercially important fisheries. Kelps are threatened globally by climate change and increased grazing pressure by marine herbivores. High abundances of sea urchins can create urchin “barrens”, which are low-productivity areas that have been denuded of kelp. In south-eastern Australia, urchin barrens caused by the native long-spined sea urchin (Centrostephanus rodgersii) are a major feature of the coastline and are increasing in some areas in response to climate change and overharvesting of top predators. Fisheries in New South Wales and Tasmania harvest urchins to extract their gonads for market, however urchins from barrens are thought to provide limited food resources, which can result in unsaleable gonads. We used in situ surveys and stable isotope analysis to investigate how gonad size, gonad quality, morphology, isotopic niche width and diet vary with depth and distance from kelp across three regions along the New South Wales coast over 700km. We found significant effects of distance from kelp and depth on urchin roe quality and gonad index. We also found urchins further away from kelp had longer jaws, smaller test diameters, lighter tests and lighter total weights compared to urchins nearer to kelp. The results of Stable Isotope Analysis showed urchins from Sydney had the widest isotopic niche space, and indicated relative contributions of kelp, turf, crustose coralline algae, detritus and invertebrates to urchin muscle tissue.

Session 11: Physiological Ecology

* indicates presenting author, † indicates eligibility for Best Student Paper Award

OCEAN ACIDIFICATION ALTERS PROPERTIES OF THE MINERALIZED EXOSKELETON IN ADULT TANNER CRABS (YOUTUBE)


1- The College of New Jersey, Department of Biology 2- NOAA, National Marine Fisheries Service, Alaska Fisheries Science Center, Resource Assessment and Conservation Engineering Division, Kodiak Laboratory 3- Florida Institute of Technology, Department of Ocean Engineering and Marine Sciences 4- The Marine Biological Association, The Laboratory, Citadel Hill

Decapod crabs produced a hard, multilayered exoskeleton, composed of chitin, protein, and mineral, predominately magnesian calcite or amorphous calcium carbonate (ACC). We investigated the effects of reduced seawater pH (ocean acidification) on the exoskeleton of mature Tanner crabs, Chionoecetes bairdi. Crabs were exposed to one of three pH levels—8.1, 7.8, or 7.5—for two years. Reduced pH led to a suite of body-region-specific effects on the exoskeleton. Microhardness, a measure of a material’s resistance to deformation, was 38% lower in the claws of crabs at pH 7.5 compared with those at pH 8.1, but carapace microhardness was unaffected by seawater pH. In contrast, reduced pH altered elemental content in the carapace (reduced calcium, increased magnesium), but not the claw. Diminished structural integrity and thinning of the exoskeleton was observed at reduced pH in both body regions; internal erosion of the carapace was present at
pH 7.5, and the claws of these crabs showed substantial external erosion, with tooth-like denticles nearly or completely worn away. Assessment of mineral phases using FTIR spectroscopy suggested a shift in the phase of CaCO$_3$ in the carapace of pH-7.5 crabs from a mix of ACC and calcite, to predominately calcite. With limited repair capacity, the exoskeleton of crabs that undergo a terminal molt may be especially susceptible to changes in ocean pH. Funding: US-NSF DMR-1905466.

SEASONAL DIFFERENCES IN FATTY ACID TROPHIC BIOMARKERS OF SEAWEEDS AND HERBIVORES IN A TEMPERATE COASTAL ECOSYSTEM (YOUTUBE)

Galloway, A.W.E$^1$; Schram, J.B.; Bell, L.; Yoshioka, R.M.; Kroeker, K.J.

1- Oregon Institute of Marine Biology 2- University of Alaska Southeast Juneau 3- University of California Santa Cruz 4- University of Oregon

Seasonal differences in light, carbonate chemistry, and water temperature in marine nearshore ecosystems can affect basal production by seaweeds. Changes to productivity and nutritional quality of seaweeds can have trophic consequences for marine invertebrate herbivores, particularly during winter months with limited light and colder water temperatures. To investigate seasonal effects on the community nearshore coastal trophic ecology, we sampled the six of the most dominant seaweeds (1 site) and six common herbivorous macroinvertebrates (3 sites) in Sitka Sound, Southeast Alaska, to compare the fatty acids of these organisms in the summer and winter. The sites and timing of the sampling was informed by previous work in Sitka Sound which has shown that this system experiences large seasonal differences in temperature and pH. We evaluated the multivariate fatty acid signatures of the producers and consumers within taxonomically related groups. We found that fatty acids for seaweeds differed among species and between seasons. Invertebrates differed between seasons and species and their interactions. Individual invertebrate species varied with respect to variation in key fatty acid categories such as essential fatty acids, saturated fatty acids, and bacterial fatty acids, but all species were significantly enriched in mono-unsaturated fatty acids in winter relative to summer.

META-ANALYSIS SUGGESTS DIFFERENTIAL EFFECTS OF INCREASING PCO2 ON STRUCTURAL AND FUNCTIONAL ATTRIBUTES OF CRUSTACEAN EXOSKELETONS (YOUTUBE)

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Crustaceans comprise a diverse taxa that inhabit a variety of ecological niches. Part of crustaceans’ ecological success is attributed to robust physiological regulatory mechanisms and, for some species, a calcium carbonate-based exoskeleton. At present, consensus on how CO$_2$-induced changes in seawater chemistry affect the structural and functional properties of marine crustacean exoskeletons is lacking. Here, we present the results from a systematic review and meta-analysis on the effects of increasing seawater pCO$_2$ levels on the elemental (calcium and magnesium content) and functional (biomechanics and thickness) attributes of Decapod and barnacle exoskeletons. Increasing pCO$_2$ levels produced complex changes in both calcium and magnesium content, with a significant decrease noted under pCO$_2$ regimes of 1500-1999 µatm. Calcium and magnesium levels predictably co-varied under lower pCO$_2$ regimes (< 1500 µatm) but not at higher pCO$_2$ levels. Exoskeletal biomechanics were negatively affected under pCO$_2$ influxes in the 500-999 µatm and 1500-1999 µatm ranges; total cuticle thickness did not significantly change under high pCO$_2$ levels. Significant levels of heterogeneity between studies were noted for all parameters. Our results suggest complex, species-specific changes in the crustacean mineralized exoskeleton under CO$_2$ influxes that warrant further consideration and care when designing acidification experiments.

TWENTY YEARS AFTER BRABY & SOMERO: SPECIES RANGE ASSESSMENT OF MYTILUS CONGENERS ALONG THE U.S. PACIFIC COAST (YOUTUBE)

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Warming seawater is providing opportunities for range expansion of marine invasive species, like that of the heat-tolerant mussel Mytilus galloprovincialis. Last assessed from 2000-2004, the species range of M. gal-
loprovincialis along the U.S. Pacific Coast extended from San Diego to Eureka, CA, with the cold-tolerant congener, M. trossulus, dominant in Oregon. However, nearly 20 years have passed since the last Mytilus range assessment and range expansion/contraction may have occurred due to climate change since their species’ range is influenced by abiotic factors. Thus, the purpose of our study was to determine the current species range of M. galloprovincialis, M. trossulus and their hybrid along the U.S. Pacific coast. We hypothesized that a greater proportion of M. galloprovincialis mussels would be present at the northerly sites compared to the proportion found historically due to warming favoring species expansion. Adult mussels (N = 30 per site) were collected at 11 different locations from San Diego, CA to Coos Bay, OR and gill tissue frozen for genetic identification. We found that the range of M. galloprovincialis was similar to the historical survey and did not expand further north as hypothesized. M. trossulus was dominant in Coos Bay but showed evidence of hybridization that was not found historically. Finally, we found evidence of hybrid zone expansion from San Diego to Humboldt Bay. Thus, our findings suggest that abiotic conditions limit M. galloprovincialis range expansion and genetic mixing has expanded between the two species along the Pacific coast.

ENVIRONMENT AND PHENOLOGY SHAPE LOCAL ADAPTATION IN THE THERMAL PERFORMANCE OF A MARINE GASTROPOD (YOUTUBE)

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Populations within species often exhibit variation in traits that reflect local adaptation and further shape existing adaptive potential for species to respond to climate change. However, our mechanistic understanding of how the environment shapes trait variation remains poor. Here, we used common garden experiments to quantify thermal performance in eight populations of the marine snail Urosalpinx cinerea across thermal gradients on the Atlantic and the Pacific coasts of North America. We then evaluated the relationship between thermal performance and environmental metrics derived from time-series data. Our results reveal a novel pattern of ‘mixed’ trait performance adaptation, where thermal optima were positively correlated with spawning temperature (cogradient variation), while maximum trait performance was negatively correlated with season length (countergradient variation). This counterintuitive pattern probably arises because of phenological shifts in the spawning season, whereby ‘cold’ populations delay spawning until later in the year when temperatures are warmer compared to ‘warm’ populations that spawn earlier in the year when temperatures are cooler. Our results show that variation in thermal performance can be shaped by multiple facets of the environment and are linked to organismal phenology and natural history. Understanding the impacts of climate change on organisms, therefore, requires the knowledge of how climate change will alter different aspects of the thermal environment.

COMBINED EFFECTS OF HEAT STRESS AND NITROGEN LIMITATION ON THE PHYSIOLOGY OF BULL KELP, NEREOCYSTIS LUETKEANA (YOUTUBE)

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High temperatures and low nitrogen (N) concentrations can be stressful for marine primary producers, yet these stressors often occur simultaneously in temperate marine ecosystems, making it difficult to unravel their effects. We used a temperature-controlled lab experiment to determine the effects of temperature (12, 16 & 20°C) and N concentrations (2 & 30 µM NO₃) on the physiology of bull kelp (Nereocystis luetkeana) sporophyte blades. After 7 days, we found significant effects of temperature on blade growth and photosynthetic physiology, and significant effects of N concentration on metabolism and nutrient uptake rates. Blade elongation rates were lowest at 20°C, but similar among 12 and 16°C treatments, while the quantum yield of photosystem II (Fv/Fm) was significantly elevated at 16°C compared to 12 and 20°C. Respiration rates were higher at 20°C, suggesting elevated metabolic demand. Nutrient uptake and metabolism measurements performed in N-rich seawater revealed that N-depleted kelp assimilated NO₃ at a significantly faster rate and achieved higher net photosynthesis compared to N-enriched kelp. After 7 days at 20°C, N-depleted blades began to degrade, preventing us from assaying this treatment, while N-enriched kelp remained intact, suggesting that low N availability may be more stressful near their upper thermal limits. Taken together, these results suggest that bull kelp populations in warm and nutrient-poor areas, including surface waters
INTERTIDAL POSITION DRIVES VARIATION IN THERMAL STRESS RESPONSE IN THE ACORN BARNACLE, BALANUS GLANDULA (YOUTUBE)
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Cal Poly, San Luis Obispo

Intertidal habitats are characterized by dynamic, tidally-driven fluctuations in abiotic factors like salinity, oxygen, and temperature. Sessile invertebrates anchored in the high intertidal zone often experience greater extremes and increased variability in these stressors compared to organisms in the low intertidal. We hypothesize that differences in the stress experience of conspecific organisms anchored in different intertidal positions (low, high) will result in variation in their thermal stress response. To investigate this, we determined the effect of an acute aerial thermal challenge, on superoxide dismutase activity (SOD), oxygen consumption rates (MO$_2$) and mortality in common acorn barnacles (Balanus glandula) collected from different intertidal positions. As expected, higher temperatures led to higher MO$_2$, but there were no differences in the magnitude of this effect between high and low barnacles. We did, however, find that high intertidal barnacles survived in elevated temperatures for longer than low intertidal barnacles. Further, B. glandula from the high intertidal showed greater SOD activity compared to barnacles from the low intertidal following 9h of exposure in heated air, though this effect was consistently independent of temperature. These data suggest that there are differences in the thermal stress response between high and low intertidal barnacles. Thus, the risks posed by intensifying climate change stress may be highly variable for resident species over very small spatial scales in the rocky intertidal habitat.

EXAMINING TRANSGENERATIONAL EFFECTS IN NATURAL POPULATIONS OF CALIFORNIA MUSSELS (MYTILUS CALIFORNIANUS) (YOUTUBE)
Chamorro, J.D.*; Hofmann, G.E.

University of California, Santa Barbara

Few studies examining transgenerational effects have been conducted on natural populations in the field. In this study, we examined the performance of offspring from mussels acclimatized to different temperature regimes (high (H) and low (L) tidal height) in situ in the rocky intertidal zone. To assess offspring provisioning we measured egg size from high and low zone mussels. To measure offspring performance, embryos from high and low mussels were raised under two temperature conditions: ambient (A ~16°C) and warm (W ~20°C), creating four offspring treatments (HW, HA, LW, LA). At the veliger stage, performance was evaluated using three metrics: body size, respiration rate, and thermal tolerance. Our results showed that maternal acclimatization had a significant effect on egg size, where high zone females had larger eggs than low zone females. For veliger larvae there was no effect of maternal acclimatization on body size, respiration rate, or thermal tolerance. However, developmental temperature had a significant effect on respiration rate and thermal tolerance, where offspring raised in the warm conditions had higher respiration rates and lower thermal tolerance than those raised in ambient conditions. These results indicate that while effects of maternal acclimatization were evident during initial investment in offspring, the temperature at which early stages developed was the dominant factor influencing offspring phenotype. Overall, this study provides insight into how and whether transgenerational effects may function in natural populations of marine organisms.

ANTICIPATING HEAT STRESS RECOVERY: ENERGY SUPPLY AND DEMAND IN IN-TERTIDAL MUSSELS (YOUTUBE)
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University of California, Irvine

The mussel Mytilus californianus aggregates into beds that shelter other intertidal species and are model organisms for assessing near-shore ecosystem health. Yet, studies show that mussel beds are declining due to rising temperatures, jeopardizing the ecological community they support. Mussel beds form across tidal and wave-exposure gradients and are subjected to fluctuating conditions. High-shore mussels are at a higher risk of heat stress as they must endure extreme temperatures for prolong periods. The heat stress response modulates energy balances: high temperatures increase repair costs, negatively impacting
growth. To understand how mussels mitigate heat stress, we investigated the temperature-sensitive cellular mechanisms of ATP supply and demand. We acclimated wild mussels in the laboratory to simulated daily cycles of low tides either at a constant 15°C or exposed to a 25°C heat shock during low tide. After acclimation, we excised gill tissue every 3 hours for 12 hours to capture the periodicity of the heat stress response. We measured gene expression of TCA cycle enzymes and heat shock proteins (HSPs) as markers for ATP supply and demand pathways, respectively. We expected heat shocked mussels to have higher expression of HSPs, signifying greater ATP demands. Interestingly, aerobic ATP-generating genes related to the TCA cycle were up-regulated in heat shocked mussels during low tide, a period of anaerobic metabolism. These findings suggest that mussels use an anticipatory strategy to prepare for heat stress recovery in upcoming high tide events.

EFFECTS OF PH AND FLOW ON CORALLINE ALGAL GROWTH AND SUSCEPTIBILITY TO URCHIN GRAZING (YOUTUBE)
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San Francisco State University

Ocean acidification (OA) and changes in the grazing behavior of purple urchin could compound to threaten coralline algae. The susceptibility of coralline algae to grazing could be heightened by a weakening of skeletal density caused by OA. Coralline algae’s unique role as both a photosynthesizing and calcium carbonate forming organism allows it to create a diffusion boundary layer (DBL) that under slow flow environments could alter the pH. The extent to which DBL’s ameliorate the effects of OA is largely unknown, as is the importance of water flow on the growth and physiology of coralline algae. We studied the effects of pH and flow on coralline algal growth and susceptibility to grazing. Crustose coralline algae (CCA) and two species of articulated coralline algae (ACA) were grown for one month in a mesocosm experiment that crossed two levels of flow with two levels of pH, then exposed them to purple urchins for 24-48 hours. Under the low flow treatment, the DBL was on average 1.7mm thick compared to the fast flow treatment where no measurable DBL was detected. Lower pH and flow had a negative effect on the growth of both ACA species but no significant effect on the susceptibility of grazing. Flow but not pH positively influenced growth of CCA. In contrast, pH but not flow negatively influenced the susceptibility of CCA to grazing. We conclude that flow regulates growth, but pH regulates grazing susceptibility in CCA, while flow and pH both regulate growth in these two ACA species but do not affect grazing susceptibility.

UNDERSTANDING CELL-CYCLE DYNAMICS UNDER FLUCTUATIONS IN OXYGEN USING MUSSEL MODELS (YOUTUBE)
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UC Irvine

Sessile mussels are facultative anaerobes that reside along coastlines worldwide and are exposed to fluctuating environments. During low tide (aerial exposure), mussels become hypoxic as they close their shell to avoid desiccation, oxidative, and thermal stress. This display of functional hypoxia makes them tractable models for understanding the architecture of facultative anaerobiosis. Evidence from a field-based study suggested that heat-stressed mussels synchronize cell division with hypoxia to avoid oxidative stress that occurs during water immersion. However, laboratory studies are needed to resolve the mechanisms of this cell division process partitioning. To understand whether environmental stress can disrupt the highly regulated cell cycle in facultative anaerobes in fluctuating environments, we studied how Mytilus galloprovincialis synchronizes cell cycle-processes during fluctuating oxygen and temperature conditions. We predicted that heat-stressed mussels would display higher levels of cell division during hypoxia than unstressed mussels. After one week of acclimation to laboratory-simulated tides at 15°C, control mussels remained at 15°C and the rest were heat-stressed at 25°C during low tide. We analyzed the gene expression of cell division markers (cyclins) in gill tissue. Remarkably, we found more robust oscillations of cyclins in heat-stressed mussels compared to control group. This novel analysis of the cell cycle in mussels may elucidate adaptations along tidal gradients and provide insight to the evolution of facultative anaerobiosis.

MULTIPLE STRESSORS INTERACT SYNERGISTICALLY TO INFLUENCE THE METABOLIC RATE OF THE MUSSEL MYTILUS GALLOPROVINCIALIS (YOUTUBE)
Climate change is predicted to influence seawater temperature and increase precipitation events that will alter salinity. These changes may influence the species range and survival of the invasive mussel, *Mytilus galloprovincialis*, which can outcompete other mussel species for space and is warm-water adapted but vulnerable to salinity changes. However, it is unknown how multiple abiotic stressors affect the physiological performance of *M. galloprovincialis*. The purpose of this study was to examine the effects of multiple stressors (temperature and salinity) on the metabolic rate (MR) of *M. galloprovincialis*. Field collected mussels were acclimated to control conditions (17°C, 34 ppt) prior to experimentation. Mussels were exposed to fully-factorial combinations of temperatures (17, 20, 25°C) and salinity (20, 28, 34 ppt), and we used a closed system respirometer to determine MR (mg O2/min./g wet weight). We found a 1.8-fold increase in MR due to elevated temperature (25 compared to 17°C). Hyposalinity exposure (20 ppt) showed a significant increase in MR. The greatest degree of synergy was observed under the most stressful treatment combination (25ºC, 20 ppt) where MR was 2.25-fold greater than that observed under control conditions. Interestingly, an antagonistic effect was observed in mussels exposed to the combination of 25ºC and 28 ppt where the MR was less than expected. Thus, our study suggests that mussels experiencing elevated temperature and moderate hyposalinity may be more vulnerable under climate change stressors due to the increased energy requirements.

**ARE SEA OTTER PUPS MORE VULNERABLE TO THE EFFECTS OF OILING?**

Given the small geographic range of southern sea otters, oil spills currently pose a significant threat to their population. It is already understood that oil contamination worsens the pelt insulation in adult sea otters, but no one has investigated how oil affects the lanugo (newborn pelage). To better understand differences in thermal function of sea otter pelts across ontogeny, we measured thermal conductivity and thermal resistance of pelts in air and in water, before and after oiling with crude oil. We tested a total of 39 sea otter pelts across six age classes: neonate, small pup, large pup, juvenile, subadult, adult. The neonatal pelage had a higher thermal conductivity in air (p<0.001) compared to juvenile, subadult, and adult pelage, suggesting lanugo pelts are poorer insulators. However, thermal resistance in air, which accounts for differences in pelt thickness, did not differ significantly across ontogeny (p=0.62). Unexpectedly, pelt thermal conductivity values in water did not vary across age classes (p=0.083), and thermal resistance in water also did not vary across ages (p=0.36). This suggests the air layer trapped within a wet otter pelt is sufficient regardless of age or pelage type. Preliminary analyses indicate similar reductions in pelt thermal function due to oiling across all ages, suggesting all sea otter age classes are vulnerable to the effects of oiling. This study is the first to investigate the effects of oil on sea otter pelage across ontogeny, with a direct comparison to the pelt’s thermal properties under normal conditions.

**THERMAL FLUCTUATIONS DURING ACCLIMATION AND ASSAY CONDITIONS ALTER MULTISCALE BIOLOGICAL PROCESSES: A META-ANALYSIS**

Thermal variability is a longstanding component of natural ecological processes and impacts organisms across both short (diurnal change) or longer (ENSO) timescales. Previous experimental work has indicated the importance of various traits and life stages in mediating organisms’ responses to variability. However, we presently lack a quantitative synthesis of the overall effects of thermal variability across a wide range of taxa and levels of biological organization. Here, we conduct two related meta-analyses that investigate how thermal variability experienced during an experiment (assay) or prior to an assay (acclimation) mediate metrics of performance, relative to organisms experiencing constant environments. Thermal moderators...
(i.e. fluctuation range, mean temperature, etc.) and trait moderators (i.e. experimental age) were statistically significant in explaining heterogeneity in both acclimation and assay model effects, though with opposite effects. Assay and acclimation models response metrics responded differently to variability within and across each analysis. Our findings suggest that when during experimentation, at what life stage, and which thermal regime an organism experiences variability, impacts downstream effects on performance. These results identify key gaps in the present empirical literature related to unanswered questions related to how thermal variability translates across levels of biological organization, study systems, and timescales.

THE EFFECTS OF RUBBLE BED DYNAMICS ON JUVENILE CORAL GROWTH RATES IN SHALLOW CORAL REEFS
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California State University, Northridge

Coral reefs have been affected by disturbances that have led to the destruction of stony coral colonies, forming beds of coral rubble in shallow reefs. Dynamic processes occurring in rubble beds, such as rubble mobilization and grazing by herbivores and corallivores, influences the diversity of rubble-dwelling organisms and the ability of unconsolidated rubble to form habitats for sessile colonizers. Exploring the interactions between coral settlers and the pieces of rubble on which they settle can enhance the understanding of rubble bed dynamics, and the potential for scleractinians to occupy space in physically disturbed environments. The objective of this study was to understand how rubble bed environments (predominantly the structural legacies of pocilloporid colonies) in the backreef of Moorea, French Polynesia, affect the abundance and physiology of corals that recruit to this habitat. Ecological assessment of juvenile distribution revealed differences in taxonomic distribution, but not abundance, between rubble beds and reef pavement. *Psammocora* occupied ~80% of the juvenile observations on rubble, while *Porites* were only ~6%. Results from an in situ experiment revealed that juvenile colonies of *Porites* and *Psammocora* grew at reduced rates in rubble beds compared to pavement substratum, but had similar rates to each within the rubble beds. Equivalent physiological responses amongst juveniles to physical processes occurring in rubble beds suggest that growth rate alone is not the mechanism driving the distribution of corals in rubble beds.

Session 12: Special Session: Marine Heatwaves II: Ecological and biological consequences of extreme warming events in coastal marine ecosystems

* indicates presenting author, † indicates eligibility for Best Student Paper Award

AN INTRODUCTION TO THE SPECIAL TOPIC SESSION ON MARINE HEATWAVES PART II
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UC Santa Barbara

Marine heatwaves (MHWs) have emerged as a threat to marine ecosystems world-wide. Here on the West coast, past events such as the ‘The Blob’, an intense heat anomaly that impacted the Northeastern Pacific coast in 2014-2016 has highlighted the degree to which MHWs can disrupt marine communities and ecosystem services. More recently, the Pacific Northwest experienced an intense aerial heatwave in June 2021. In this special topic session, Marine Heatwaves, Part II, we will again highlight advances in the study of marine heatwaves, with a special set of presentations on observations made by our colleagues during and after the June 2021 heat dome event. Our session is especially meant to highlight work by diverse, early career researchers who are making outstanding contributions to the study of MHWs, and the associated ecological consequences of thermal stress experienced by marine ecosystems and marine organisms. Overall, our sessions goal is to introduce graduate students to the topic of MHWs as these extreme disturbance events are likely to be a persistent climate-change related event that Western Naturalists will face in the future (and there could be some important and intriguing thesis topics in there as well!). We hope you will join us!

FISH ASSEMBLAGE STRUCTURE BEFORE AND AFTER A MARINE HEATWAVE IN WEST HAWAI’I ISLAND (YOUTUBE)
Olsen, A.Y.*; Larson, S.E.; Padilla-Gamiño, J.L.; Klinger, T.
Coral reefs are subject to marine heatwaves caused in part by human-induced climate change. Long-term thermal stress can negatively affect corals and the associated marine organisms that use these areas as critical habitat. In this study, we examined fish community response to climate change by analyzing changes in assemblages following a marine heatwave. We collected 11 years of subtidal video survey data in three areas on the west side of the Big Island of Hawai‘i, capturing a marine heatwave event from 2014 – 2016 in the middle of the dataset. Fish were counted and identified to species, then assigned to one of seven functional groups: predators, secondary consumers, planktivores, corallivores, scrapers, grazers and browsers. Our study revealed three key findings. First, we show that regardless of habitat differences and management strategy, all fish assemblages became more homogeneous after the marine heatwave. Second, we found that only eight species drove most of the changes in functional groups across locations. Third, following the marine heatwave, fish abundance increased in the areas with fewer fishing regulations, and appeared to remain high and relatively stable in a more protected area. Understanding how marine heatwaves impact coral reef communities may guide decision-making for effective coastal management. Continued long-term monitoring is necessary to evaluate impacts on this coral reef ecosystem as marine heatwaves and other climate related disturbances increase in frequency.

ASSESSMENT OF AN UNPRECEDENTED HEATWAVE ON INTERTIDAL SHELLFISH OF THE SALISH SEA

From 26 - 28 June 2021, the Pacific Northwest of North America experienced an unprecedented atmospheric heatwave that coincided with the lowest low tides of the year. During and immediately following the event many local scientists, resource managers, and members of the general public reported dead and dying marine organisms including barnacles, mussels, clams, and oysters. In response we developed semi-quantitative survey to assess effects of and resilience to the heatwave on nearshore invertebrates. Our goal was to rapidly inventory observations across a broad geographic scale to assess general status of intertidal species post-heatwave and to serve as a starting point for future quantitative research and monitoring. Nearly all species observed, including barnacles, mussels, oysters, and various clam species, experienced negative effects of the heatwave. The degree of negative effects appear to be driven by natural history of the species and modulated by sub regional variation in the timing of low tide, exposure, and local environmental factors. While many of our observations were negative, pockets of resilience were observed in nearly all species, highlighting locations which may be resilient to a continuing warming climate. We hope that these observations spur quantitative efforts to describe the ecological, fisheries, and societal impacts of the heatwave and provide insight for adapting management of intertidal species in a warming climate.

INTERTIDAL EELGRASS DECLINE UNDER COMBINED EFFECTS OF WASTING DISEASE AND WARMING (YOUTUBE)

Ocean warming threatens vital coastal ecosystems, including eelgrass (Zostera marina) meadows. At meadows along the Pacific coast of North America, outbreaks of seagrass wasting disease are correlated with warm water anomalies. In the Salish Sea, outbreaks have increased since 2013 and can infect 90% of plants in individual meadows. From 2019-2021, we assessed the interactive stressors of warming temperatures and disease outbreaks in intertidal meadows in the San Juan Islands, WA and throughout the region. Our sur-
veys captured complex site-specific dynamics, with extreme regression of the upper intertidal area and/or decreased density of the meadow coinciding with high incidence of wasting disease at some sites. Outbreaks of wasting disease may serve as an early warning for subsequent loss of portions of intertidal meadows. In June 2021, we documented extreme temperatures during the heat dome, exceeding 35ºC during low tides at some intertidal meadows in Washington. However, shoot densities remained similar to prior summers at some locations over the short term (days to weeks following the heating event). These results highlight the complexity of seagrass response to warming events, with both duration and intensity of exposure contributing factors to ecosystem impacts. Sustained warming that facilitates wasting disease infection may be particularly damaging for seagrass meadows under climate change.

NOT THEIR FIRST RODEO? MUSSEL MORTALITY AT A KNOWN HOT-SPOT FOLLOWING A HISTORIC HEAT WAVE (YOUTUBE)
Emily Carrington*; John W. Little; Robin J. Fales; Kindall A. Murie; Kenneth P. Sebens
University of Washington
On June 26-29, 2021, the Pacific Northwest was subjected to a record-shattering ‘heat dome’, with air temperatures exceeding 35C for several days. The extreme heat wave coincided with spring daytime low tides, exposing intertidal organisms to potentially lethal aerial conditions. Indeed, reports of mass mortalities were widespread, especially for epibenthic bivalve mollusks like mussels and oysters. We assessed mortality and size distribution of the California mussel (Mytilus californianus) in the days following the heat dome at Cattle Point on San Juan Island, WA, a known thermal hot-spot for the west coast of North America. Biomimetic ‘robomussels’ indicated mussels were at risk for lethal thermal stress, with maximal daily temperatures (34-48 C) near or exceeding the thermal tolerance reported for this species (up to 36 C). Surprisingly, only 1.4% of the population was lost, suggesting the population had higher thermal tolerance than expected and/or experienced lower temperatures than estimated by robomussels due to evaporative cooling or inhabiting cooler microclimates. As expected, mussel body size (shell length) of the underlying population decreased with increasing height on the shore (+0.4-1.3 m above MLLW). However, the mean size of dead mussels did not vary with tidal height; mortality was biased toward larger mussels in the high zone, and smaller mussels in the low zone. These findings suggest an overall high thermal margin of safety for this population, and that heat waves may select for larger, older individuals in lower zones on the shore.

DEATH, DESTRUCTION, AND OTHER ECOLOGICAL IMPACTS OF THE 2021 WESTERN HEAT DOME EVENT (YOUTUBE)
1- University of British Columbia 2- Hakai Institute 3- Simon Fraser University
Late June, 2021, saw record-setting temperatures across much of western North America with often severe consequences for wildlife and people. Here, we summarize our observations during and following this heat dome event on intertidal shores. Temperatures in the intertidal zone in excess of 50 C were measured during the event, which coincided with very low tides. Dozens of species were adversely affected in British Columbia, including sea stars, sand dollars, clams, oysters, dogwhelks, limpets, crabs, and some low intertidal kelps. Mussels (Mytilus trossulus), barnacles (Balanus glandula and Chthamalus dalli), and rockweed (Fucus distichus) suffered extensive mortality. At local spatial scales, this mortality was especially severe on south and southwest facing surfaces. Mortality was greatly reduced on north-facing surfaces and - for invertebrates - in areas with protective algal canopies. At larger scales, mortality was particularly high in the Strait of Georgia, Puget Sound, and protected fjords on the central British Columbia coast, and declined towards more wave-exposed shores and areas where the low tides occurred earlier in the morning. Interestingly, many introduced species did not experience high levels of mortality, which may reflect their relatively warm regions of origin. The medium-term consequences of the extensive loss of habitat-forming species, the time required for these species to recover, and the long-term trajectory of intertidal communities in the face of increasingly frequent and severe heatwaves remain to be determined.

LARGE-SCALE SHIFT IN THE STRUCTURE OF A KELP FOREST ECOSYSTEM CO- OCCURS WITH AN EPIZOOTIC AND MARINE HEATWAVE (YOUTUBE)
Climate change is responsible for increased frequency, intensity, and duration of extreme events, such as marine heatwaves (MHWs). Within eastern boundary current systems, MHWs have profound impacts on temperature-nutrient dynamics that drive primary productivity. Bull kelp (Nereocystis luetkeana) forests, a vital nearshore habitat, experienced unprecedented losses along 350 km of coastline in northern California beginning in 2014 and continuing through 2019. These losses have had devastating consequences to northern California communities, economies, and fisheries. Using a suite of in situ and satellite-derived data, we demonstrate that the abrupt ecosystem shift initiated by a multi-year MHW was preceded by declines in keystone predator population densities. We show strong evidence that northern California kelp forests, while temporally dynamic, were historically resilient to fluctuating environmental conditions, even in the absence of key top predators, but that a series of coupled environmental and biological shifts between 2014 and 2016 resulted in the formation of a persistent, altered ecosystem state with low primary productivity. Based on our findings, we recommend the implementation of ecosystem-based and adaptive management strategies, such as (1) monitoring the status of key ecosystem attributes: kelp distribution and abundance, and densities of sea urchins and their predators, (2) developing management responses to threshold levels of these attributes, and (3) creating quantitative restoration suitability indices for informing kelp restoration efforts.

ABALONE SURVIVORS OF MARINE HEAT WAVES HAVE LASTING HEALTH IMPACTS

Rogers-Bennett, Laura*; Klamt, Robert; Catton, Cynthia

BML UC Davis

Marine heat waves (MHW) impact marine populations and contribute to the collapse of kelp forest ecosystems yet we have little understanding how the survivors are impacted. Abalone are key resources that are recreationally fished and depend on kelp forest habitats. However, abalone have experienced mass mortality following 2014-2016 MHW in northern California. We examine the survivors and quantify the declines in abalone body and gonad condition. The survivors had 25% less body mass than before the MHW. Gonad indices had dramatic decreases of roughly 75%. Similarly, egg production per gram of female body weight declined by an estimated 75% compared with the pre kelp forest collapse time period. Starvation led to declines in both gonad volume (20%) and egg density (46%) and impacted the relationship between shell length and body weight. Abalone reproduction was resilient for one year after the MHW and kelp forest decline in 2014 but by 2016 and 2017 surviving females had reduced egg production. Maturation of eggs and sperm was stunted however, immature eggs and spermatids were still present. It is unknown if abalone once fed could reverse the trends and resume successful gamete maturation. The poor reproductive potential of these populations indicates that MHWs can have long lasting impacts for populations and communities beyond the MHW period.

SPATIAL VARIATION IN THE BENTHIC REEF COMMUNITY OF KIRITIMATI ISLAND AFTER A CORAL MASS MORTALITY EVENT

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1- University of British Columbia 2- University of Victoria 3- Pacific Community

Anthropogenic climate change is increasing the frequency of marine heatwaves, making mass coral bleaching and mortality an increasingly common event on coral reefs. Previous studies have shown that the relative abundance of coral and algae species before and after coral mortality varies with depth and wind exposure. To assess spatial variation in benthic composition on Kiritimati’s reefs three years after a severe coral mass mortality event, I used benthic photo quadrats to survey shallow and deep sites at exposed and sheltered locations on the atoll’s uninhabited southern coast. I measured the proportional cover of coral, crustose coralline algae (CCA), turf algae, and fleshy macroalgae, as well as the abundance of juvenile Acropora and Pocillopora colonies. I found that abiotic cover, turf algae, CCA, and coral cover varied with depth and wind exposure. Coral cover was highest at deep sites and exposed locations, where stress-tolerant corals likely made up a larger proportion of the coral community before the mass mortality event. Higher CCA cover at
shallow exposed sites, higher fleshy macroalgae cover at deep sites, and higher turf algae cover at exposed locations were consistent with lineage-specific tolerances for light, wave action, and sedimentation. Juvenile Acropora and Pocillopora abundances were low and varied only with depth, which had a genus-specific effect on abundance. These findings illustrate how local environmental conditions before, during, and after coral mass mortality can shape the benthic communities of coral reefs.

EXPLORING THE DEVELOPMENTAL CONSEQUENCES OF HEAT STRESS DURING FERTILIZATION IN THE PAINTED SEA URCHIN LYTECHINUS PICTUS
† Leach, T.S.*; Hofmann, G.E.

University of California, Santa Barbara

With the increasing frequency of marine heatwave (MHW) events, understanding their impacts on coastal ecosystems is essential. In the Pacific Northwest, the timing of the most extreme MHW temperatures often aligns with the seasonality of summer-reproducing species, making these groups particularly relevant to research focused on the effect of MHW events. Early developmental stages of marine invertebrates are often the most vulnerable to environmental stressors, like temperature, but the extent that carry-over effects across life history stages influence these vulnerabilities is not fully understood. For this study, we investigated the impact that elevated temperatures during fertilization have on later development in the summer-spawning sea urchin, *Lytechinus pictus*. Pooled urchin sperm and eggs were exposed to one of three temperatures mimicking ambient summer (17ºC), current MHW-like (21ºC), or future MHW-like (24ºC) conditions before conducting fertilization assays. From these fertilizations, subsets of the resulting embryos were raised under the original temperature conditions as well as those corresponding to temperatures +/- 3ºC. The goal was to investigate how the temperature experienced at fertilization affected (1) fertilization success and (2) subsequent developmental performance, as measured by developmental progression, body size, and normality. While fertilization success negatively correlated with temperature, the developmental performance of embryos under varying temperatures was not significantly impacted by fertilization temperature.

Drone-based monitoring of a potential eelgrass recovery following an estuary-wide collapse in a major California estuary (YOUTUBE)
† Tallam, Krti†*; Ryan Walter; Andrew Fricker

1- Stanford University 2- California Polytechnic State University, San Luis Obispo, CA

In shallow coastal and estuarine habitats, seagrass meadows are declining at an alarming rate, resulting in the loss of important ecosystem services. Morro Bay, an estuary in central California, historically supported one of the state’s largest eelgrass (*Zostera marina*) populations. However, from 2007 to 2017, intertidal eelgrass in Morro Bay underwent an unprecedented collapse, declining from 139.2 ha (344 acres) in 2007 to 5.4 ha (13 acres) in 2017. The estuary-wide loss of eelgrass resulted in drastic changes, ranging from a shift in fish species composition and loss of habitat specialists to widespread erosion in places that previously supported eelgrass. As part of a funded project that recently ended, drone-based surveys from December 2017 to December 2019 showed signs of partial recovery with total eelgrass acreage going from 5.4 ha (13.3 acres) to 14.9 ha (36.7 acres). This, combined with recent successful small-scale restoration efforts led by the Morro Bay National Estuary Program (MBNEP), suggests that Morro Bay may be going through another major period of transition and possible reemergence of the major biogenic habitat. It is critical to continue to track eelgrass acreage during this time with important ramifications for the physical, biological, and chemical environment.

CORAL BLEACHING RESPONSE TO MARINE HEATWAVE MEDIATED BY WATER DEPTH AND CORAL COLONY SIZE
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The 2019 Indo-Pacific bleaching event was the most severe in the region’s recent history. Relatively deep layers of warm seawater induced coral bleaching throughout the region, yet neither warming nor bleaching was
uniform across space. Warming and bleaching intensity are generally assumed to decline with water depth, thus providing a refuge for corals during marine heatwaves. Whether depth refuges are ubiquitous in space and impact corals of different taxa and size is poorly understood but is important to assess the ecological effects of bleaching. To test whether and how bleaching varied with water temperature, depth, colony size, taxa, and location on the fore reef of Moorea, French Polynesia, we surveyed and recorded bleaching severity for more than 5000 coral colonies of the two dominant genera, Acropora and Pocillopora. Overall, Acropora bleached more severely (76% of colonies were 75% dead and/or bleached) than Pocillopora (22%). Both genera experienced depth and size refuges from bleaching but the magnitude of safety afforded by each refuge substantially varied, depth being more important for Acropora and size for Pocillopora. Bleaching patterns for each genus were driven by accumulated heat stress (AHS) and mean daily temperature fluctuation (MDTF) during and leading up to the onset of bleaching. Our analysis indicated that Acropora corals bleach at lower levels of AHS than Pocillopora in Moorea, but Acropora colonies in deeper water or those exposed to high MDTF were generally spared from bleaching.

**DIY MHW FOR THE BUDGET SCIENTIST: AN AFFORDABLE SYSTEM DESIGNED TO SIMULATE MARINE HEATWAVES IN THE LABORATORY**

de Leon Sanchez, E.E.1; Devlin, M.R.; Hofmann, G.E.

1- Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara 2- Department of Mechanical Engineering, University of California, Santa Barbara

Marine heatwaves (MHWs) are predicted to increase in frequency, duration, range, and intensity due to anthropogenic climate change. Studies have shown that MHWs impact species abundances, biogeographic range shifts, and fisheries landings. To predict the severity of these consequences, we must understand species’ physiological thermal thresholds. Complicating this need, many practitioners of marine ecophysiology are limited to short-term acclimation periods with static temperatures that are not fully reflective of in-situ conditions. The facilities and equipment required to simulate a MHW in a laboratory are also costly, often requiring customized simulators from aquatic design and manufacturing companies. Here, we designed a MHW simulator (MHWSim) for a modestly sized (~three 30-liter tanks) continuous flow-through system. Instead of using traditional static temperature controllers, we use a Raspberry Pi, an inexpensive and commercially available microcontroller board, and implemented it in Python to have novice-friendly programmable control over the MHW experiment. The Pi is connected to D218B20 temperature probes and a titanium heater to have closed loop feedback control over any desired temperature. Preliminary data from the MHWSim demonstrated that we can design and control dynamic warming events to mimic the in-situ conditions that have been recorded by sensor arrays deployed by the Santa Barbara Coastal Long Term Ecological Research. Most notably, the MHWSim is relatively affordable at under $2,000, creating a more equitable approach for MHW laboratory experiments.

**PHYSIOLOGICAL IMPACTS OF THE PNW HEATDOME ON AN INTERTIDAL KELP: HIGH SURVIVAL WITH TISSUE LOSS**

† Fales, R.J.; Carrington, E.

University of Washington Dept. of Biology & Friday Harbor Laboratories

Climate change is increasing the frequency and severity heatwaves, both marine and aerial, as evidenced by the unprecedented aerial heatwave which occurred in the Pacific Northwest (‘PNW heat dome’) in June 2021. The PNW heat dome coincided with afternoon spring tides in the Salish Sea which was unfortunate timing for intertidal organisms, including the kelp *Hedophylhum sessile*. While most kelps are subtidal, *H. sessile* is a habitat-forming foundation species in the low intertidal zone, and experiences long periods of emersion. We investigated the physiological tolerance of *H. sessile* to aerial heat stress during low tides in lab experiments and a field study on San Juan Island, WA. During May and June 2021, we exposed entire sporophytes to simulated 3-hour low tide treatments (hot, ambient, and submerged) for 4 consecutive days and measured physiology metrics and survival during the experiment and after a submerged recovery period. In the field, we measured lengths and bleaching of adult sporophytes during bi-monthly low tide sequences from May to August, including during the PNW heat dome. Together, these studies indicate *H. sessile* can survive extreme heat waves, but with large amounts of tissue bleaching and subsequent loss of distal blade tissue. Nonetheless, even with high survival, there could still be long term negative effects due to the
energetic cost of lost tissue during heatwaves. Additionally, there could be cascading community impacts
due to a habitat-former having less blade area to create a shaded microhabitat.

Does exposing oysters to warmer temperatures and tidal inundation in the lab affect their
growth and mortality in the field? (YOUTUBE)
Shukla, Priya1*; Burge, Colleen M.; Kowshik, Samaresh R.; Grosholz, Edwin (Ted) D.
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Marine heatwaves threaten the economically important oyster aquaculture industry in California. Not only
do increased seawater temperatures pose a physiological challenge for oysters, but warmer waters can also
amplify disease outbreaks. In Tomales Bay, where several aquaculturists operate, oysters are grown in tidally
influenced environments where ostreid herpesvirus (OsHV-1) also infects the Pacific oyster, *Crassotrea gigas*,
during summer months. One potential strategy for coping with these abiotic and biotic challenges is to
‘stress harden’ oysters prior to outplanting them. To initiate stress hardening, we exposed oysters (C. gigas
and C. sikamea) to a combination of temperature (16°C vs 21°C) and tidal treatments (cyclical immersion v.
constant immersion) for two weeks in the lab. To create the temperature treatments, we heated two sumps to
16°C and 21°C that directly replenished tanks housing oysters. To simulate tidal inundation, we programmed
a Raspberry Pi to control electrically actuated ball valves that opened and closed at six-hour intervals. We
then outplanted oysters across three sites (18 bags at each site with 175-250 oysters in each bag) that span a
naturally occurring temperature gradient in Tomales Bay. Two temperature loggers that measured air and
water temperature were also installed at each site. Over two months, we monitored growth and mortality,
which differed across the sites and among lab exposure treatments. Ultimately, stress hardening may only
be an effective strategy under certain conditions.

Session 13: General Session 1

* indicates presenting author, † indicates eligibility for Best Student Paper Award

WHERE THE WIND BLOWS: OCCURRENCE AND DISTRIBUTION OF SPECIES OF CONCERN IN A FUTURE OFFSHORE WIND ENERGY AREA (YOUTUBE)
Haulsee, D.E.1*; Matthew W. Breece; Dewayne A. Fox; Matthew J. Oliver
1- Stanford University 2- University of Delaware 3- Delaware State University

Technological advances and changes in national energy policy objectives have increased interest in U.S. off-
shore wind energy. The coastal ocean off the US Mid-Atlantic has particularly good conditions for offshore
wind energy projects and contains multiple Wind Energy Lease Areas (WEAs). The Delaware (DE) WEA
is located approximately 11 km from the coastline, but little is known about the distribution and occurrence
of marine species in this area. Between 2017-2019, an acoustic telemetry array recorded observations of At-
lantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), winter skate (*Leucoraja ocellata*), and other acoustically
tagged species in the DE WEA. A generalized additive model (GAM) was created to predict the occurrence
and distribution of Atlantic sturgeon using remotely sensed ocean surface parameters (temperature, color),
modeled ocean bottom temperature, and seafloor characteristics (bathymetry, sediment grain size, and bot-
tom temperature). This model expands on similar models produced for Atlantic sturgeon in the area but
captures the distribution of Atlantic sturgeon further offshore than previously observed. Atlantic sturgeon
residency occurred year-round, but shifted offshore and was highest in November and December. Few tagged
winter skate were detected in the DE WEA, indicating that there is a low risk of offshore wind development
impacting this commercial stock in this WEA. Our study provides the information necessary to implement
impact reduction strategies during the construction and operation of future wind energy projects in this
region.

LIFE HISTORY AND ABIOTIC FACTORS MEDIATE INTERACTIONS BETWEEN THE PERENNIAL GIANT KELP AND AN ANNUAL INVASIVE ALGA (YOUTUBE)
Ryznar, E.R.1*; Fong, P.; Lloyd-Smith, J.O.
1- CA Sea Grant/Delta Stewardship Council 2- UC Los Angeles
**Sargassum horneri**, a brown alga, invaded the California coast in 2003. Despite its rapid spread, little is known about factors influencing its population structure or how it may be interacting with the native foundation species, giant kelp (*Macrocystis pyrifera*). To address these gaps, we developed stage-structured population models for both species driven by light and temperature and evaluated their interactions. To assess drivers of *S. horneri* population structure, we compared model outputs with light and temperature relationships to field dynamics. To evaluate each species’ “invasion” potential into mature stands of the opposite species, we simulated recruitment at different levels of interspecific competition and assessed population trajectories. Model simulations for *S. horneri* aligned with field dynamics. Further, *S. horneri* could not invade kelp during peak recruitment months, but persisted longer when invasion preceded minima in large kelp stages. In contrast, kelp recolonized when large *S. horneri* stages were sparse and competition was low. Our results suggest that light, temperature, and intraspecific competition structure *S. horneri* populations. Further, *kelp and*S. horneri interactions are mediated by different life histories, with kelp dominance aided by continuous reproduction and perennial persistence, and *S. horneri* success limited by seasonal reproduction and annual senescence that releases resources. Our results imply that *S. horneri* invasion depends on disturbances that remove kelp.

**THE ROLE OF CORALLINE ALGAE IN KELP FOREST RECOVERY** *(YOUTUBE)*

Twist, B.A.1*; Zaklan Duff, S.D.; Pearce, C. M.; Martone, P.T.

1- University of British Columbia 2- Vancouver Island University 3- Fisheries and Oceans Canada

Dramatic shifts from healthy kelp forests to urchin-dominated barrens have become prevalent in recent years, severely impacting ecosystems and local economies. Research to-date has focused mostly on top-down effects and their impacts on recovery with little attention paid to bottom-up effects, such as those derived from coralline algal communities present in these systems. Coralline algae play critical and species-specific roles in nearshore ecosystems, inducing invertebrate larval settlement and influencing kelp spore settlement and germination. Furthermore, coralline communities can differ significantly between urchin barren and kelp forest habitats, perhaps helping to maintain either ecosystem state. The settlement patterns of the red urchin and several common kelp species were assessed on a range of molecularly identified coralline algal species in the laboratory. Fewer differences in urchin metamorphosis and juvenile canopy-forming kelp density were observed than expected across coralline species. This perhaps suggests the generality of urchin and canopy-forming kelp recruitment to barrens, regardless of coralline composition. A secondary sub-canopy kelp species, however, preferentially settled on articulated coralline species not typically found in urchin barren habitats, suggesting that benthic coralline communities would need to recover before this sub-canopy species could return. These results could have important implications for kelp forest recovery following changes in coralline community structure in urchin-dominated barrens.

**RUBBISH RESIDENTS: DEBRIS-ASSOCIATED FISH COMMUNITIES IN THE PACIFIC GARBAGE PATCH** *(YOUTUBE)*

† Benadon, C.M.*

*Smithsonian Environmental Research Center and Bowdoin College*

Marine debris is entering the ocean at unprecedented rates, yet little is known about how communities engage with this introduced substrate. Groups of displaced fishes, such as coastal and reef-residing species, have been observed to congregate around floating anthropogenic debris. This study is the first to describe a) these fishes' community composition, and b) the flotsam properties that influence fish association. I review underwater photographs from several cruises in the North Pacific Subtropical Gyre during 2018-2020, recording debris properties and identifying associated fish species. Community analysis reveals three key trends. First, fish communities around marine debris are characterized by low diversity (mean Shannon = 0.43, Simpson = 0.25). Second, individual debris items have highly dissimilar species composition (mean Bray-Curtis = 0.90). Third, different fish species preferentially associate with certain debris-centered ecosystems. Additionally, the data suggest that debris type and the presence of the gooseneck barnacle *Lepas* affect fish community structure. Fish species composition varies due to item type (ANOVA, p = 0.007) and *Lepas* colonization (ANOVA, p = 0.013). These findings provide a glimpse into the structure of, and influences on, a previously unstudied community.
THE COAST IN COVID
Anderson, S.S.*
CSU Channel Islands

The initial months of the COVID-19 outbreak afforded us a powerful “experiment” in the form of pandemic-induced homestay and altered behaviors. Lockdown afforded us a unique lens with which to quantify our wider environmental impact. An array of interrelated research suggests the first year of the pandemic was a watershed event for coastal resources. Among other insights, we have documented greatly expanded appreciation of and use of the coast (up to several orders of magnitude greater visitation), altered seafood consumption, reduced wildlife kill rates on coastal roadways (despite vehicle trips only being reduced by ~30%), and growing imperilment of our iconic sandy beaches (most visibly highlighted by the apparently COVID-19 spurred Huntington Beach Oil Spill). In aggregate, our coastal systems are seen as being even more precious by an ever wider swath of the public just as their future grows ever more tenuous.

Drift algae accumulation and their important role as ecological subsidies in Antarctica
† Garrido, I.*; Pardo, L.M.; Hawk, H.; Bruning, P.; Johnson, L.E.
1-Université Laval 2- Universidad Austral de Chile

Many aquatic communities rely on external subsidies that provide energy and nutrients. Drift algae can function in this way, and in polar regions, the processes producing detached algae and their subsequent accumulation on the bottom can be controlled by ice scouring. Observations made in Fildes Bay (Antarctica) suggest that the local disturbance in shallow soft bottoms by icebergs can produce long and narrow hollows in the seabed (i.e., ice pits). These bottom features tend to accumulate detached macroalgae between depth of 12 and 18 m. These accumulations are usually colonized by conspicuous benthic faunal assemblages. Although drift algae appear to be a major ecological subsidy on soft bottoms in Antarctic, their deposition in ice pits have been poorly described, and their ecological role remains unknown. The objective of this study was to characterize the distribution of drift algae in the subtidal soft bottom habitats in Antarctica and document its importance in creating habitat and driving benthic community diversity. A total of 17 ice pits of 12m2 average area were sampled. A high species richness was observed (16 macroalgae and 25 faunal species) comparable to adjacent benthic rocky reefs. Ice pits thus appear to be key feature of subtidal habitats in soft-bottom regions, where algae accumulated in them provide both habitat and food resources to a surprisingly high biodiversity of invertebrates and are likely important breeding areas for isopods, amphipods and fish. More information is needed on the extent of ice pits and their stability over time.

Kelp-forest dynamics controlled by substrate complexity (YOUTUBE)
Randell, Z.H.1*; Kenner, M.; Tomoleoni, J.; Yee, J.; Novak, M.
1-Oregon State University 2- U.S. Geological Survey

The factors that determine why ecosystems exhibit abrupt shifts in state are of paramount importance for management, conservation, and restoration efforts. Kelp forests are emblematic of such abruptly-shifting ecosystems, transitioning from kelp-dominated to urchin-dominated states around the world with increasing frequency, yet the underlying processes and mechanisms that control their dynamics remain unclear. Here, we analyze four decades of data from biannual monitoring around San Nicolas Island, CA, USA, to show that substrate complexity controls both the number of possible (alternative) states and the velocity with which shifts between states occur. The superposition of community dynamics with reconstructions of system stability landscapes reveals that shifts between alternative states at low-complexity sites reflect abrupt, high-velocity events initiated by pulse perturbations that rapidly propel species across dynamically-unstable state-space. In contrast, high-complexity sites exhibit a single state of resilient kelp-urchin coexistence. Our analyses suggest that substrate complexity influences both top-down and bottom-up regulatory processes in kelp forests, highlight its influence on kelp-forest stability at both large (island-wide) and small (<10m) spatial scales, and could be valuable for holistic kelp forest management.
STRUCTURAL COMPLEXITY AND SPATIAL HETEROGENEITY MEDIATE HERBIVORY LEADING TO SPATIAL ASYNCHRONY AND STABILITY IN ALGAL COMMUNITIES
† Srednick, G.S.†; Swearer, S.E.

University of Melbourne

Variation in the abundance of populations and communities over time and space can have important effects on the stability and resilience of ecosystems. Asynchronous dynamics among species or localities have been demonstrated as drivers of temporal stability in metacommunity structure by buffering variation at the local scale. However, there is little empirical understanding of the drivers of species asynchrony in natural marine systems. We established an herbivory experiment in Moorea, French Polynesia on 10 x 10 cm^2 algal settlement plates to understand the drivers of spatiotemporal asynchrony in community dynamics. Specifically, we tested the hypotheses that prey detectability (spatial heterogeneity) and accessibility (habitat complexity) individually and interactively (1) reduce the rate of herbivory on algae, (2) lead to differences in the trajectory and composition of the algal community and (3) can lead to stabilizing spatial asynchrony in algal community structure at the metacommunity scale. A 74-d experiment revealed that decreased accessibility reduced the rate of herbivory and the composition of the algal community, however increased detectability led to stabilizing spatial asynchrony on algal community structure when compared with communities with low detectability. We suggest that heterogeneity in the effects of herbivory driven by physical habitat structure can modulate algal species composition, patterns of succession, and the stability of marine algal communities.

ANTHROPOGENIC-MEDIATED SHIFTS IN THE TROPHIC STRUCTURE OF CORAL REEF FISHES (YOUTUBE)
† Willert, M.S.†; Hay, M.E.

Georgia Institute of Technology

A multitude of anthropogenic stressors including global climate change, resource exploitation, and species invasion is shifting trophic interactions in ecosystems, resulting in the trophic downgrading of modern oceans. Coral reefs provide a host of ecosystem services, are especially threatened by anthropogenic stressors, and may provide an example of trophic downgrading. Localized stressful events and their effects on community interactions of coral reefs have been well studied, but there has been limited documentation of the impacts of these stressors on trophic structure across broad temporal or spatial scales. While field studies cannot recreate historical food webs, stable isotope analysis of museum collections can address these complex questions by assessing historic shifts in trophic relationships within and across communities. In this study, d15N values from museum specimens of mesopredator fishes from Caribbean reefs were compared from 1860 to the present to evaluate possible downwarding of trophic positions on modern Caribbean reefs. Mesopredators showed a significant decline in d15N values through time, suggesting trophic decline over the past 160 years. Understanding the nuanced relationships between trophic structure and anthropogenic disturbances will help illuminate the complex effects of stressors on marine ecosystems and allow for an enhanced ability to conserve these systems.

Session 15: General Session 3

* indicates presenting author, † indicates eligibility for Best Student Paper Award

Correcting richness estimates based on observed abundance and spatial distributions (YOUTUBE)
Tekwa, E.W.; Whalen, M.A.; O’Connor, M.I.

University of British Columbia

Species richness is an essential biodiversity variable and a conservation objective. However, varying survey effort and spatial aggregation level means species are often missed to different extents, making it difficult to estimate true richness and compare communities across space and time. Here we present a new and simple correction method based on modelling how abundance and spatial distributions affect the observation process.
The quantities needed are often already measured in biodiversity surveys, with no need to independently estimate detectability or other metadata. We demonstrate the method’s effectiveness in simulated data and a real multi-year near-shore dataset. The results improve our ability to estimate biodiversity and detect change.

MICROPARTICLE VARIABILITY IN THE SALISH SEA: DOCUMENTING THE GLOBAL COVID-19 PANDEMIC (YOUTUBE)
Harris, Lyda*; LaBeur, Laura; Olsen, Amy; Smith, Angela; Eggers, Lindsey; VanBroeklin, Jennifer; Pedersen, Emily; Brander, Susanne; Larson, Shawn
1- Seattle Aquarium 2- Oregon State University

Anthropogenic debris including microparticles (MP; <5mm) are ubiquitous in marine environments. The Salish Sea experiences seasonal fluctuations in precipitation, river discharge, sewage overflow events, and tourism— all variables previously thought to have an impact on MP transport and concentrations. Our goals are two-fold: 1) Describe long-term MP contamination data including concentration, type, and size and 2) Determine if seasonal MP concentrations are dependent on environmental or tourism variables in Elliott Bay, Salish Sea. We sampled 100 L of seawater at depth (~9 m) at the Seattle Aquarium approximately every two weeks 2019 – 2020 and used an oil extraction protocol to separate MP. We found MP concentrations ranged from 0 – 0.64 particles L⁻¹ and fibers were the most common type observed. Microparticle concentration exhibited a breakpoint on April 10, 2020, where estimated slope and associated MP concentration significantly declined. Further, when considering both environmental as well as tourism variables, temporal MP concentration was best described by a mixed-effects model with tourism as the fixed effect and the person counting MP as the random effect. While monitoring efforts presented here set out to identify effects of seasonality and interannual differences in MP concentrations, it instead captured an effect of decreased tourism due to the global Covid-19 pandemic.

POPULATION MONITORING AND MANAGEMENT ACTIONS OF THE GREEN ABALONE AT GUADALUPE ISLAND, MEXICO (YOUTUBE)
† Bauer, J.†; Segovia-Rendón, J.; Beas-Luna, R.; Lorda, J.
1- Universidad Autónoma de Baja California (UABC) 2- Proyectos y Servicios Marinos (PROSEMAR)

The green abalone, *Haliotis fulgens*, is a gastropod mollusk of high economic value, extracted for more than 35 years at Guadalupe Island. Unlike other sites in Mexico, Guadalupe Island’s green abalone population is considered stable despite extraction and environmental variability. To evaluate the population characteristics of the species and understand its relative success, we developed an ecological and fishing monitoring supplemented with a restocking effort through translocations and no-take zones. To assess the population structure around Guadalupe Island, we deployed 192 transects of 60 m² at 33 sites, obtaining a total area of 11,700 m². We recorded 2238 abalones, equal to a density of 0.21 abalones per m². We analyzed the fishery catches to characterize the size structure and the weight-length ratio in the different fishing grounds around the Island. In addition, to increase the population density, we marked, measured, and sexed 461 adult abalones, and then translocated them to two no-take zones. After 18 months, the two no-take zones implemented in this work tripled the density (0.6 abalones per m²) and we registered an increment in shell length. We developed this work with members of the fishing cooperative, who were trained for monitoring and translocation activities. Abalones and other benthic species are limited in their ability to escape the effects of climate change. In this work, we expose how the combination of some management actions can enhance a sustainable fishery.

ECOSYSTEM-BASED MANAGEMENT FOR KELP FORESTS (YOUTUBE)
† Hamilton, S. L.†; Gleason, M. G.; Godoy, N.; Eddy, N.; Grorud-Colvert, K.
1- Oregon State University 2- The Nature Conservancy

Kelp forests line a quarter of the world’s coastlines and provide diverse ecosystem services. While kelps are a harvested resource themselves, they are also foundation species that form the basis of productive ecosystems. Globally, kelps are threatened by a variety of anthropogenic impacts, including overharvesting, overgrazing, invasive species, poor water quality, and the direct and indirect effects of climate change. To address these
threats and preserve the services provided by these foundation species, we show that Ecosystem-Based Management (EBM) approaches are well-suited for kelp forest management. To define and illustrate key EBM-inspired approaches for kelp forest management and conservation, we combined key concepts from the EBM literature and the literature on the biology and ecology of kelp forests as well as primary information we gathered on case studies of ongoing kelp forest management at regional levels in British Columbia (Canada), California (United States), and northern Chile. Using these three sources of information, we identify six key concepts for kelp forest EBM: 1) monitoring at biologically relevant temporal and spatial scales, 2) assessing and addressing cumulative impacts, 3) managing across spatial scales, 4) co-management with users, 5) employing rapid adaptive management and/or the precautionary principle, and 6) managing food web connections. We explore and illustrate these concepts using examples from multiple regions to provide concrete guidance on EBM-inspired strategies that are likely to improve kelp forest management.

PERCEPTIONS OF VULNERABILITY IN U.S. WEST COAST FISHING COMMUNITIES

† Nelson, L.K.*; Levin, P.S.; Koehn, L.E.; Cullen, A.C.; Bogeberg, M.A.

1- University of Washington 2- University of Washington and The Nature Conservancy Washington 3- The Nature Conservancy Washington

In the coastal socio-ecological fisheries systems (SEFs) of the California Current, the wellbeing and economies of human communities are closely tied to the health of fish and shellfish populations, rendering benefits from and relationships with nature vulnerable as the abundance and availability of marine species are affected by climate change. The resulting vulnerability is distributed unequally and is a function of the exposure of an individual or community to climate impacts, sensitivity to that exposure, and capacity to adapt to the effects of climate change. Acknowledging that people often experience climate vulnerability in different ways, we conducted a survey to understand the perspectives of fishers in Washington, Oregon, and California regarding their exposure, sensitivity, and adaptive capacity. We also asked about observations of ocean change, levels of concern regarding numerous issues that affect fishing success, and investigated various aspects of individual and community wellbeing. Most survey respondents reported observations of change in fisheries and the environment; changes that they said have raised stress levels and negatively affected overall wellbeing. While there was some variability in vulnerability based upon fishery participation, we found that beliefs held about climate change were the most significant driver of perceptions of vulnerability. Lastly, people who saw themselves as more highly exposed and sensitive to the impacts of climate change also tended to have higher concerns about non-environmental issues that may affect fishing.

Session 16: General Session 4

* indicates presenting author, † indicates eligibility for Best Student Paper Award

THE COMPLETE MITOCHONDRIAL GENOME OF THE ATLANTIC GHOST CRAB OCYPODE QUADRATA (FABRICIUS, 1787) (BRACHYURA: OCYPOLIDAE) (YOUTUBE)

† O’Brien,C.*; Braken,H.; Baeza,J.A.

1- Clemson University 2- Florida International University

The semi-terrestrial Atlantic ghost crab Ocypode quadrata inhabits the supralittoral zone in sandy temperate and tropical beaches of the western Atlantic ocean. Despite the relevant ecological role of O. quadrata and its use as a bio-indicator, there are currently a few genetic and genomic resources for this species. This study assembled and characterized in detail the complete mitochondrial genome of O. quadrata from Illumina short paired-end reads. The software Novoplasty assembled and circularized the complete mitochondrial genome of the Atlantic ghost crab with an average coverage of 162x per nucleotide. The AT-rich mitochondrial genome of O. quadrata is 15,547 bp in length, consisting of 13 PCGs, 22 transfer RNA (tRNA) genes, and two ribosomal RNA genes (rrnL and rrnS). A single 685 bp long non-coding nucleotide region is assumed to be the D-loop/Control region. A selective pressure analysis indicates that all the PCGs are under purifying selection. The 22 tRNA genes range from 64 to 70 bp in length, and all the tRNAs showed a conventional “cloverleaf” secondary structure except for trnS1 that was missing the D-arm, in agreement to that reported for other brachyuran crabs. A maximum likelihood phylogenetic analysis based on all PCGs that included a
total of 18 species of crabs fully supported the monophyly of the family Ocypodidae. This study represents a new genomic resource for this ecologically relevant bioindicator ghost crab.

**HOW TO OPTIMIZE BIODIVERSITY CENSUS SAMPLING USING MULTIPLE METHODS: A FRAMEWORK AND NEW R PACKAGE (YOUTUBE)**

† Hawk, H.L.*; Ferrario, F.; Johnson, L.E.

*Université Laval*

Whether for an experiment or a survey, investigators must make a great number of decisions about how to best characterize a marine system, and the method of observation can strongly impact what assemblages are detected and how biodiversity is calculated. Inefficiencies and census biases arise when sample attributes cause mismatches with local ecological processes and species phenology. These attributes include size and device type (e.g., quadrat, bottle, fishing pole, etc.) and environmental decisions like depth, duration, time of year, time of day, and many more. Here, we describe a framework and a new R package, SampleMinds, designed to alleviate some of this methodological bias by generating cost-effective, multi-method protocols for sampling dynamic species pools. Given species data from different sample types (i.e., methods or variations on a single method), protocols with unique effort allocation across combinations of sample types are generated, resampled, and compared in terms of 1.) the necessary number of sample types to reach census levels and 2.) the proportion of the species pool detected per unit of effort. As a case study, we compare 17 variations on the recruitment tile method for censusing biofouling assemblages within a marina in British Columbia, Canada. Also, since sampling decisions are often driven by price tags, cost calculators (per-unit, per-event) allow the comparison of multi-method protocols in terms of cost-effectiveness and the implementation of budgets.

**NONADAPTIVE RADIATION OF THE GUT MICROBIOME IN AN ADAPTIVE RADIATION OF CYPRINODON PUPFISHES WITH MINOR SHIFTS FOR SCALE-EATING (YOUTUBE)**

Joseph Heras*; Christopher Martin

1- California State University, San Bernardino 2- University of California, Berkeley

Adaptive radiations offer an excellent opportunity to understand the eco-evolutionary dynamics of gut microbiota and host niche specialization. In a laboratory common garden, we compared the gut microbiota of two novel trophic specialists, a scale-eater and a molluscivore, to a set of four outgroup generalist populations from which this adaptive radiation originated. We predicted an adaptive and highly divergent microbiome composition in the specialists matching their rapid rates of craniofacial diversification in the past 10 kya. We measured gut lengths and sequenced 16S rRNA amplicons of gut microbiomes from lab-reared fish fed the same high protein diet for one month. In contrast to our predictions, gut microbiota largely reflected 5 Mya phylogenetic divergence times among generalist populations in support of phylosymbiosis. However, we did find significant enrichment of Burkholderiaceae bacteria in both lab-reared scale-eater populations. These bacteria sometimes digest collagen, the major component of fish scales, supporting an adaptive shift. This contrasts with predictions of adaptive radiation theory and observations of rapid diversification in all other trophic traits in these hosts, including craniofacial morphology, foraging behavior, aggression, and gene expression, suggesting that microbiome divergence proceeds as a nonadaptive radiation.

**IMPORTANCE OF PLASTICITY IN THE COPEPOD CLIMATE RESPONSE (YOUTUBE)**

† Ashlock, L.W.*; Crooker, J.R.; Darwin, C.B.; deMayo, J.A.; Dam, H.G.; Pespeni, M.H.

1- University of Vermont 2- University of Connecticut, Avery Point

Copepods are major drivers of nutrient cycling, connect primary producers to higher trophic levels, and are an essential food source for forage fishes. Copepods that occupy estuaries experience fluctuations in temperature and salinity, requiring them to respond to multiple stressors at different time scales. Importantly, the relative roles and limitations of plasticity and adaptation in this response are not well understood. Here, we examined the response of the estuarine copepod, *Acartia tonsa*, to warming across development, three generations, and +25 generations. To determine the difference in thermal tolerance among groups, we subjected copepods to Upper Lethal Temperature (ULT) assays. Additionally, to identify costs of warming to salinity tolerance we
examined the Lower Lethal Salinity of copepods after warming. We saw the largest increase in ULT in the
developmental temperature treatment, with no additional increase in ULT with three and +25 generations at
warming. This demonstrates the importance of plasticity in the copepod climate response. Additionally, we
saw a diversification of ULT values after developmental warming, indicating that development at a warmer
temperature can reveal cryptic phenotypic variation. Interestingly, we found no cost of experimental warming
on salinity tolerance. However, when we subjected copepods to reduced salinity before evaluating ULT, we
saw a reduction in ULT with lower environmental salinity. This indicates that *A. tonsa* may be vulnerable
to continually changing temperature and salinity conditions.

**LITTLE SHARKS IN A BIG WORLD: PHYLOGEOGRAPHY OF THE CALIFORNIA
HORN SHARK (YOUTUBE)**
† Canfield, S.J.*; Bowen, B.W.

*University of Hawaii at Manoa*

Assessing connectivity among populations of marine organisms is critical to the development and implement-
tion of conservation measures. To date, population genetic studies in sharks have focused on large-bodied,
highly mobile species, while smaller, coastal species with limited dispersal potential have received little atten-
tion. The California horn shark (*Heterodontus francisci*) is a small, benthic shark inhabiting the East-Pacific
coastline from California, U.S.A. to the Gulf of California, Mexico. This species is known to maintain rel-
atively small home-ranges as adults and exhibit strong site-fidelity. To assess connectivity across the range
of *H. francisci*, we analyzed a 724-bp fragment of the mitochondrial control region (mtCR), as well as a
ddRADseq dataset consisting of 9,063 putatively neutral SNP loci. Both datasets indicate that deep (> 200
m), cold-water channels are an effective barrier to dispersal in *H. francisci* across incredibly small spatial
scales (< 20 km), and SNP analysis identified three distinct populations in the Southern California Bight:
the Northern Channel Islands (consisting of Anacapa Island and Santa Cruz Island), Santa Catalina Island
to the south, and the California mainland. Our analyses indicate that barriers limiting the dispersal of
demersal elasmobranchs can exist at spatial scales much smaller than previously detected.

Session 17: General Session 5

* indicates presenting author, † indicates eligibility for Best Student Paper Award

**EFFECTS OF MODEL COMPLEXITY ON DESCRIBING AND FORECASTING SPECIES
RESPONSES TO CLIMATE CHANGE**

Essington, T.E.

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Alaska Regional Office NOAA Fisheries 4- Fisheries and Oceans Canada 5- University of Washington

Species distribution models (SDMs) are commonly used to quantify habitats of marine fishes. However, we
lack information about how these statistical models perform when predicting fine-scale population metrics in
the near-term. We compared the performance of various SDMs when describing historical patterns in habitat
use and forecasting responses to future conditions. We used conventional methods to assess the performance
of in-sample model predictions and retrospective skill testing to compare out-of-sample forecasts with obser-
vations of Arrowtooth Flounder (*Atheresthes stomias*) and Walleye Pollock (*Gadus chalcogrammus*) in the
Bering Sea. Complex dynamic SDMs outperformed all others when quantifying past distributions and densi-
ties, whereas static SDMs exhibited greater forecast skill. Sharper declines in forecast skill were likely driven
by a prevalence of temperatures much warmer than those used in model fitting. Model performance and
forecast skill were also related to niche breadth, with poorer predictability for the more broadly distributed
species. Although complex dynamic SDMs are unequivocally superior for estimating historical distributions
and densities, static model forecasts or persistent forecasts from dynamic SDMs may be more skillful in
quantifying fine-scale population metrics under novel conditions. Here, we demonstrate the utility of ret-
rospective skill testing in identifying the most appropriate model before forecasting responses under novel
conditions.
Modeling the effectiveness of holding cages and hatcheries in managing Philippines blue swimming crab fisheries (YOUTUBE)
Ng, Gabriel1*; Espino, Marillene; Mesa, Sheryll

1- Smithsonian Environmental Research Center 2- Philippine Association of Crab Processors, Inc 3- Bureau of Fisheries and Aquatic Resources

Fisheries are an important aspect of global food production, but for many, such as the blue swimming crab (Portunus pelagicus) fishery in the Philippines, stock abundance has dropped significantly due to over harvesting. One method to mitigate the effects of overharvesting is to allow gravid females to release their larvae before processing the crabs. This strategy can be implemented by placing females in holding cages or to culture harvested eggs in hatcheries. However, the efficacy of larval release has not yet been measured. We constructed a theoretical population model as a first step in estimating the efficiency of these release methods. The model tracks the survival of a cohort of crab larvae until they attain market size accounting for both natural mortality as larvae and juveniles and additional fishing mortality. We estimate about 0.002% of larvae survive to an adult size of 115mm in carapace width, suggesting that around 4400 crabs and 1600 crabs are added to the adult population every year for hatcheries and holding cages respectively. These estimates show that neither management strategies are necessarily cost effective, but there is substantial variability within these estimates that arises from a lack of robust field mortality estimates for larvae. Despite the uncertainty, the model provides promising avenues to improve yield from the management strategies and next steps to ground truth the results using field surveys.

HERITABILITY OF LIFE-HISTORY TRAITS IN STEELHEAD INFERRED FROM A MULTIGENERATIONAL PEDIGREE ANALYSIS (YOUTUBE)

1- University of California, Santa Cruz 2- Universidad Autónoma de Baja California 3- Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration 4- Agricultural Research Service, US Department of Agriculture

A large, multigenerational pedigree was used to elucidate life-history patterns of anadromous steelhead (Oncorhynchus mykiss) from the Russian River in Northern California, USA. We determined age structure, and estimated the heritability of age at maturity and spawn timing in ocean-going fish using genetic analyses with SNP data from ~18,000 adult steelhead returning to two locations in the basin over 14 years. Analysis of age structure revealed a strong presence of age-2 fish, that only spend one year at sea, which is unusual in the species. To understand the genetic basis of age at maturity and therefore the opportunity for selection on it in the hatchery environment, we estimated narrow-sense heritability using several methods. We found a relatively high heritability, with variation between sexes. The heritability was highest in females, but only 7.2% of females returned to the hatchery at age 2, limiting power. Date of spawning was also found to be highly heritable. This supported previous findings and yielded a very high estimate of 76% of additive genetic variation for spawn date in this population. The findings of substantial heritability of age at maturity and timing of reproduction in these protected steelhead emphasizes the high opportunity for selection on these critically important traits due to a variety of anthropogenic factors, including hatchery practices and ecosystem modifications.

CLIMATE VULNERABILITY ASSESSMENT OF ECONOMICALLY IMPORTANT FISHERY SPECIES OF BAJA CALIFORNIA, MEXICO
† Mansfield, E.J.1*; Grewelle, R.E.; De Leo, G.; Micheli, F.

1- Hopkins Marine Station of Stanford University 2- Hopkins Marine Station of Stanford University, Center for Ocean Solutions of Stanford University

The world’s small-scale fisheries (SSFs) face threats from a variety of different climate change factors. An ability to comprehensively understand this threat and how it contributes to the vulnerability of the fisheries and the coastal communities that depend on them is crucial in developing effective management and adaptation to this global change. In this study, we modified the Productivity-Susceptibility Analysis (PSA) approach for fishing to determine the aggregated risk to climate change of economically important fisheries
species in Baja California, Mexico. Vulnerability to changes in water temperature, dissolved oxygen, and ocean pH were determined and aggregated to project a species’ overall risk to forecasted future climate change. Aggregated vulnerability to multiple climate threats tends to result in a higher overall vulnerability classification as compared to vulnerability to a single climactic stressor, highlighting the importance of comprehensive understanding of all climate threats. This risk-based assessment provides information about possible future impacts of climate change on local ecosystems and economies, particularly within data-poor fisheries. It can help advise the development of management and adaptive social strategies to increase the resilience of SSFs in the face of multiple stressors.

Session 18: General Session 6

* indicates presenting author, † indicates eligibility for Best Student Paper Award

DO HOST POPULATIONS CONSISTENTLY DIFFER IN THEIR LEVELS OR TYPES OF PARASITISM THROUGHOUT THEIR GEOGRAPHIC RANGES? (YOUTUBE)
† Novoa, A †; Ryan F Hechinger

UC San Diego, Scripps Institution of Oceanography

Many basic patterns concerning parasitism and host biogeography remain undocumented, much less understood. This knowledge gap is particularly troublesome given rising numbers of species changing their distributions in response to global climate change. Using a hypothesis-driven framework, we document patterns of parasitism throughout entire geographical ranges of four estuarine fish species to ask: Do host populations have different levels or types of parasites at range edges compared to range centers? Are there differences in parasitism at northern versus southern range boundaries? Consistent with the hypothesis based on the latitudinal diversity gradient, mean parasite richness per host individual increased at lower latitudes for all fish species. Mean richness of a specific functional group of parasites, trophically transmitted parasites, increased at lower latitudes for three fish species, consistent with the hypothesis that predation is more intense near southern limits. Parasite biomass load (g parasite/ g host) showed two dominant patterns, being highest at northern or southern edges, suggesting the factor hypothesized as underlying the latitudinal diversity gradient in parasite richness may sometimes counter a parallel southern increase in parasite biomass load. Understanding how parasitism varies throughout species geographic ranges provides fundamental ecological insight and helps inform predictions concerning impacts of global warming induced range shifts.

OCEANIC INPUT BUFFERS THE IMPACTS OF GLACIAL MELT ON ROCKY INTER-TIDAL TROPHIC DYNAMICS (YOUTUBE)

1- College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, Alaska 2- College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, Alaska

Global warming has increased the rate and extent of glacier mass loss resulting in changes of land-to-ocean flux altering biodiversity and ecosystem function. Identifying how climate induced glacial recession and melt will alter nearshore trophic dynamics can help inform stakeholders how to best cope with future conditions. We utilized two regions that differ in oceanic input with naturally occurring gradients of glacial coverage to help predict how glacial melt may affect trophic dynamics between seaweeds and consumers. To isolate seaweed morphological effects and estimate consumption rates, we used a controlled laboratory setting to feed two common intertidal herbivores a common brown alga from their source region and site ad libitum every 3-4 weeks over 5 months. Consumption rates were generally consistent for both herbivore taxa and differed by region and site. In the region with less oceanic input, rates were higher on macroalgae from the sites with less glacial coverage, and in the region with more oceanic input, rates were more equal across sites. Preference experiments between macroalgae at sites with low and high glacial coverage conducted in both regions corroborated the consumption rate findings. In the region with less oceanic input, macroalgae from the low glacial coverage site was preferred while preference did not differ significantly between sites in the region with high oceanic input. These data suggest that glacial recession and melt will alter nearshore trophic dynamics and that oceanic input may help buffer against these changes.
GEOGRAPHIC VARIATION IN KEYSTONE PREDATION (YOUTUBE)
Gravem, S.A.1; Pete Raimondi; Laurel Field; Alexis Necarsulmer; Bruce Menge
1- Oregon State University 2- UC Santa Cruz

The keystone predation hypothesis is a fundamental ecological theory, but it is unknown whether its importance is widespread or geographically variable. The original keystone predator, the sea star *Pisaster ochraceus*, is widely-thought to exert top-down control of intertidal communities by freeing space, thereby increasing biodiversity. The coast-wide sea star wasting disease epidemic in 2013-2014 was a unique opportunity to test the keystone predation theory on a coast-wide scale. We surveyed 33 rocky intertidal sites along the Oregon and California coasts since 2015 to track change in low zone community structure. While there was substantial site-to-site variation, our preliminary findings suggest that the decline in sea stars was followed by an increase in spatially-dominant mussels and a decline in biodiversity over several years in Oregon and Southern California, but not in Northern or Central California. This suggests that the role of *Pisaster* as a keystone predator is widespread, but the strength of the effect is locally or regionally-controlled. Further, it suggests that some communities (primarily in Northern and Central California) were resilient to the effects of the trophic downgrade caused by sea star wasting disease.

THERMAL HISTORY, HEATWAVES, AND THE COSTS AND BENEFITS OF PLASTICITY OF THE CALIFORNIA MUSSEL (MYTILUS CALIFORNIANUS) (YOUTUBE)
† Brownlee, G.R.P.
University of British Columbia

Climate change has and will continue to increase mean summer aerial temperatures and the intensity and frequency of heatwave events with damaging effects on intertidal species. While the long-term viability of a population may depend on processes like adaptation, plasticity in thermal tolerance can support a population’s resistance to rapid changes in thermal regimes on shorter timescales. Using *M. californianus*, an important foundation species on rocky shores, I explored plasticity in lethal and cardiac thermal tolerance and their consequences via a long-term acclimation experiment coupled with seasonal tolerance assessments and post-heatwave mortality surveys in Bamfield, BC. I found that lethal thermal tolerance increased with increasing acclimation temperatures and acclimatization, but this effect was more pronounced in the lab than in the field. Maximum heart rates also increased with acclimation temperature, but flatline and critical temperatures did not change. Finally, gonadosomatic index – a proxy for reproductive capacity – was lower in individuals that experienced higher acclimation temperatures. While *M. californianus* can be plastic in its lethal and cardiac thermal tolerances and may yet be able to express further plasticity in the field in response to changing thermal regimes, expressing that plasticity comes at a cost to reproduction and was insufficient to fully protect range-center populations during the June 2021 heatwave.

OXYGEN AVAILABILITY REGULATES RESPONSES OF MARINE INVERTEBRATES TO OCEAN WARMING – A CASE STUDY IN THE CALIFORNIA CURRENT SYSTEM (YOUTUBE)
Duncan, M.I.1; Boag, T.H.; Marquez, J.A.; Deres, H.; Deutsch, C.; Sperling, E.A.; Micheli, F.
1- Stanford University 2- Yale University 3- Princeton University

Climate change is driving warming and deoxygenation of the world’s oceans, directly affecting organisms which may respond by shifting their distributions. The direction and magnitude of observed distribution shifts are variable, complicating proactive management strategies, but considering the underpinning physiological mechanisms can increase forecasting accuracy. Building on principles of metabolic physiology we develop an absolute metabolic index (AMI), akin to absolute aerobic scope, but quantitatively incorporating effects of temperature, oxygen availability and organismal mass, and test its predictive utility for red abalone (*Haliotis rufescens*) and purple urchin (*Strongylocentrotus purpuratus*) in the California Current System. We find close matches between optimal temperatures predicted by AMI for abalone (17 °C) and urchin (11.5 °C) with comparable aquaculture studies and that temperatures where AMI is maximized given the prevailing oxygen availability tightly match conditions at geo-referenced occurrences, indicating AMI does have predictive utility. Projecting species-specific calibrations of AMI onto high-resolution current and future (2100) ocean models predicts that suitable abalone habitat will become fractured and reduced while
urchin habitat will be relatively unaffected. This study highlights how the integration of physiology into predictions of biological responses to climate change can produce vastly different outcomes among species and the role of oxygen availability in moderating the thermal response of organisms.

Session 19: General Session 7

* indicates presenting author, † indicates eligibility for Best Student Paper Award

**WHAT DRIVES SHELL FORMATION IN THE MARINE MUSSEL, MYTILUS CALIFORNIANUS?** (YOUTUBE)

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1- Friday Harbor Laboratory 2- Bodega Marine Laboratory

Many marine organisms produce calcium carbonate shells or skeletons. This process, calcification, can be particularly sensitive to shifts in seawater carbonate chemistry. Multiple correlated components of the seawater carbonate system, however, make it difficult to distinguish between various proposed controls on calcification from single parameter perturbation experiments. Here, we report findings from experiments where we decouple key components of the carbonate system to ascertain effects each might have on shell formation. We undertook these experiments with adults of the marine mussel, *Mytilus californianus*, a common habitat forming species on the west coast of North America. After experimentally accounting for abiotic dissolution of existing shell material, we found that calcification was positively correlated with bicarbonate ion concentration, a substrate in the shell formation process, and, independently, pH as excess protons can inhibit the removal of waste products from the site of calcification. Further, neither the combination of these two parameters into the commonly used substrate-to-inhibitor ratio (SIR) nor the highly correlated calcium carbonate saturation state were good predictors of calcification rate. These results indicate that a single parameter description of how chemical alterations impact marine calcifiers may not be adequate given the complex chemistry of coastal ecosystems.

**DETECTING GENOMIC SIGNATURES OF SALINITY TOLERANCE IN TILAPIA USING POOLSEQ** (YOUTUBE)

† Barba, Evan, W†; Seale, Andre, P; Toonen, Rob, J

1- Hawai‘i Institute of Marine Biology 2- UH Mānoa

Understanding how genetic exchange between populations varies is key to identifying hotspots of diversity, sinks and sources, and regions potentially predisposed to resiliency. When targeting specific regions known to be influenced by environmental factors, many other regions that are influenced may be overlooked. With ezRAD based sequencing, we can affordably scan across entire genomes, however the cost of individual genome scans is high compared with single-marker studies. Pooled sequencing (pool-seq) approaches offer a compromise that may be well suited for gathering population genetic data across many individuals and broad geographic areas. However, analyzing pooled data currently is computationally challenging and unstandardized, requiring heavy formatting or programming skills. Our pipeline (AssessPool) utilizes bash and R code to process a file of identified single nucleotide polymorphisms (SNPs) and implements a series of tools to identify regions of genomic differentiation between pools of populations. Here we demonstrate the utility of pool-seq and AssessPool using a genome-wide scan to identify loci at functional regions displaying significant differentiation associated with environmental salinity in tilapia. Isolated stocks of Mozambique Tilapia (*Oreochromis mossambicus*) were reared in both fresh water and seawater treatments, which were sampled using pool-seq as separate populations to identify regions of significant genomic differentiation. Further analysis of these results may inform future physiological research on salinity acclimation in fish.

**METABOLIC SCALING OF SCLERACTINIAN CORALS DIFFERS AMONG THEIR LARVAE, JUVENILE COLONIES, AND TAXA** (YOUTUBE)

† Bean, N.K.*; Edmunds, P.J.

California State University Northridge

Body size and the way in which physiological traits scale with size have profound implications for organismal performance. Metabolic scaling examines the relationship between metabolic rate and mass with a power
function having a scaling exponent, $b$. The value of $b$ provides insights into how metabolic energy is utilized by organisms and it remains relatively unexplored in marine modular colonial organisms. This study focuses on tropical reef corals and tests the hypothesis that metabolic scaling differs among brooded and broadcasted larvae, juvenile colonies, and taxa. The study objectives were achieved using a compilation of published respiration rates and empirical data collected in Moorea, French Polynesia. Organism-specific aerobic respiration was independent of size ($b = 0.04$) in brooded larvae, but it scaled isometrically in broadcasted larvae ($b = 0.9$) and juvenile pocilloporids ($b = 0.99$), and allometrically in juvenile poritids ($b = 0.65$). To gain insight into potential factors mediating variation in $b$, biomass and protein content of juvenile corals was measured. Dry tissue in juvenile Pocillopora spp. and Porites spp. colonies scaled isometrically ($b=0.98$) and allometrically ($b=2.07$) with surface area, respectively; protein content in both taxa scaled with an exponent of 0.69 on dry biomass. These results suggest that biomass and tissue composition mediate metabolic rates. Metabolic rate is important because it is linked with other important physiological processes (e.g. growth), which can scale up to influence organismal performance and ecosystem dynamics.

ANALYSIS OF HEAT SHOCK PROTEIN 90 DURING THE MATERNAL-TO-ZYGOTIC TRANSITION IN STRONGYLOCENTROTUS PURPURATUS (YOUTUBE)
† Gill, J.R.*
Sonoma State University

The impact of rising ocean temperatures on early embryonic stages of meroplankton is an important area of study. The purple sea urchin (*Strongylocentrotus purpuratus*) is a bioindicator of kelp forest ecosystems and well-known model organism. We investigated how heat stress impacted protein abundance of heat-shock protein 90 (hsp90) in *S. purpuratus* during the maternal-to-zygotic transition (MZT). The MZT is a critical stage of embryogenesis when maternal mRNAs and proteins are eliminated and the zygotic genome gains control of transcription. Many client proteins of hsp90 are directly involved in embryogenesis. We hypothesized hsp90 expression would remain low, even when thermally stressed, during the MZT due to the limited transcriptional capacity of an embryo, making hsp90 a capacitor for phenotypic plasticity. Current results suggest 2-cell and hatched blastula stage embryos raised in ambient (13 °C) and elevated (18 °C) temperatures modeled the typical pattern for increased protein abundance when exposed to a 1-hour heat-shock. Protein suppression was evident in early gastrula embryos raised in ambient temperatures where, after heat-shock, protein abundance declined. In contrast, embryos of the same stage reared at elevated temperatures, showed an increase in protein abundance when subjected to heat-shock. Hsp90 is both a constitutive and inducible heat-shock protein which may explain why it is elevated in some cases but not others. This still leaves much room for future investigation on how the expression of hsp90 changes throughout embryonic development.

EFFECTS OF OCEAN ACIDIFICATION ON BLUEBANDED GOBY REPRODUCTIVE OUTPUT AND BEHAVIOR (YOUTUBE)
† Ambat, D.S.*; Edwards, M.S.
San Diego State University

The effects of ocean acidification (OA) are well-described for calcifying marine invertebrates. By contrast, fewer studies examined how OA affects fishes, and many of these studies have produced confounding results. Understanding the effects of OA on fish reproduction, a process that is pivotal to maintaining population dynamics, is of paramount importance to nearshore fisheries and proper ecosystem functioning. To examine the effects of lowered seawater pH on bluebanded goby (*Lythrypnus dalli*) reproductive output and behavior, two experimental treatments were established that represent present-day (ambient) and future (decreased by 0.2 pH units) pH conditions. Sexually mature bluebanded gobies were placed in laboratory mesocosms for continuous seven-day trials and allowed to reproduce in artificial nests. Four artificial nests were placed in each of the four mesocosms to provide fish with similar nesting habitats and to encourage reproduction. Each mesocosm included similar fish size structures and number of females to control for any size- or sex-dependent responses. Reproductive behavior was quantified by daily, visual analysis of movement patterns of the focal male within each mesocosm during all experimental trials. Nests were checked daily and any eggs present were photographed. Reproductive output was quantified by the number and size of eggs deposited on acetate sheets in artificial nests. Results indicate that decreased seawater pH did not significantly impact
Cooperation in the management of shared fish stocks is often necessary to achieve sustainability and reduce uncertainty. The United States of America (USA) and Mexico share several fish stocks and marine ecosystems, and while there is some binational cooperation in scientific research, unilateral management decisions are prevalent. How do these management and research asymmetries skew national perceptions of population status of transboundary species? We present a case study using the giant sea bass (*Stereolepis gigas*, Polypri-onidae) and find large differences in national perceptions. Scientific publications and annual funding related to giant sea bass are 7x and 25x higher in the USA, respectively, despite the fact that 73% of the species’ range occurs in Mexico. Conversely, annual fishery production and consumptive value of giant sea bass in Mexico are 19x and 3.5x higher than in the USA, respectively, while the non-consumptive value related to dive ecotourism is 76x higher in the USA. These asymmetries have generated a distorted view of the population status of the giant sea bass across its entire range. This and other factors related to historical fishery dynamics and policy must be accounted for when assessing population status, and subsequent appropriate management responses, across geopolitical boundaries.

**Preliminary analysis of population structure in Mytilus californianus using coalescent methods**

† Garcia, V.R.†; Crandall, E.D.; Jue, N.

*1- California State University, Monterey Bay 2- Pennsylvania State University*

Most marine organisms have a dispersive larval phase that is released into the water column to drift on ocean currents. Because population dynamics of many marine species are governed by the recruitment of these larvae, it is important to be able to estimate the distance and direction that larvae disperse. In species with relatively continuous distributions, spatially restricted larval dispersal is expected to create a process of isolation-by-distance, which should lead to distant population pairs showing, on average, greater genetic divergence than adjacent population pairs. Such a pattern can be used to estimate the size of dispersal “neighborhoods”, which could be key to the advancement of marine population ecology and conservation efforts. The California mussel, *Mytilus californianus*, is a commercially important species with a larval stage that can drift for up to 45 days. Even with this long duration, it should be expected that this species will exhibit isolation by distance along its distribution, which spans thousands of kilometers from Baja California to Alaska. However, previous studies investigating population genetic structure in this species, have failed to detect any population structure whatsoever. This study aims to characterize the metapopulation structure of *M. californianus* and explore the possibility of detecting faint but meaningful structure by fitting coalescent models of stepping-stone gene flow and isolation-by-distance. Preliminary results of these analyses will be presented.
Since the rapid decline of the southern sea otter population, numbers have rebounded but remain far below historical estimates. In the 50 years since mortalities have been recorded, disease has been the primary source of mortality. Among disease, acanthocephalans of the genus *Profilicollis* are the leading primary and contributing cause of death, killing 11-26% of sea otters. Despite the significance of this parasite to sea otter survival, little is has been quantified about its life history and transmission. Leveraging a 50 year necropsy dataset of greater than 10,000 otters, a 20 year dataset of infested intermediate host crabs, and detailed analysis of the parasite in several bird host species, we resolve the epidemiology of this parasite. We use mechanistic, machine learning, and statistical models to reveal drivers of infestation and mortality in sea otters, which are dead end and accidental hosts. This represents the first longitudinal epidemiological study of the acanthocephalan phylum and maps sources of risk related to this parasite for a recovering sea otter population.

**PROJECTION MATRIX MODELS REVEAL INTRA-COLONY DYNAMICS OF DIFFICULT-TO-OBSERVE COLONIAL ORGANISMS**

† Metz, D.C.G.*; Hechinger, R.F.
Scripps Institution of Oceanography, University of California, San Diego

Colonial organisms such as the well-known ants, bees, corals, and siphonophores are cooperative groups of separate bodies living together and united by a shared germline. Many colonies are difficult to observe across time, as they live inside nests or food sources, such as termites in wood, snapping shrimps in sponges, or trematodes in snails. However, a generally unappreciated fact gives us the power to probe their inner workings: colonies are analogous to closed populations of free-living individuals. We show that any colony can be easily represented by a projection matrix model. The simplicity of these models and their foundation in real biological processes – birth, growth, and death rates – allows us to explore the intra-colony dynamics and developmental biology of otherwise difficult-to-observe colonial organisms. Here, we apply a stage-structured matrix colony model to trematodes, among the most difficult-to-observe of the social animals. Trematodes form colonies inside their molluscan hosts and some form castes of soldiers and reproductives. We address two outstanding questions concerning the drivers of trematode social organization. First, are soldier worms a permanent defensive caste, analogous to some non-reproductive insect workers? Second, do trematode colonies typically turn over, or do individuals in a colony live as long as their host? In addition to answering these questions, we conclude by describing how projection matrices can be more broadly applied to shed light on the developmental biology and social organization of other colonial organisms.

**EFFECT OF MUSCLE CONTRACTIONS ON GAMETE PLUMES DURING THE REPRODUCTIVE SPAWNING OF THE RED ABALONE, HALIOTIS RUFESCENTS**

† Wu, M.L.V.*; Paig-Tran, E.W.M.; Forsgren, K.L.; Nichols, K.; Zacherl, D.C.
CSU Fullerton

Free-spawning marine animals such as the red abalone, *Haliotis rufescens*, aggregate and synchronously release their gametes into the water column for external fertilization. Red abalones are known to contract their muscular bodies while spawning, which may increase gamete dispersal by pushing plumes of gametes higher up into the water column, ushering them within reach of other spawning adults, though the impact of this contraction behavior on gamete dispersal has not been studied. I hypothesized that the velocities of eggs and the heights of egg plumes would increase with increasing contractile forces. I measured the contractile forces of fifteen female adult red abalones and captured the egg velocity and the heights of the resultant egg plumes using high-speed videos and Go Pros during chemically induced free-spawning events at the Cabrillo Marine Aquarium, San Pedro, California between September 2019 and February 2020. The egg velocities and egg plume heights were positively and non-linearly impacted by contraction forces between 400 and 800 mN. Abalones possessing an open third respiratory pore had plumes that were 11.5% taller than the average plume height of 23.4 cm, and gonad width positively correlated with egg plume heights. This latest information about the impact of abalone contraction force on egg velocities and gamete plumes will enhance our knowledge of abalone reproductive behaviors, launch future studies, and guide restoration strategies and
policies for protected abalone species.

Session 21: General Session 9

* indicates presenting author, † indicates eligibility for Best Student Paper Award

DETERMINING THE EFFECTS OF MARINE HEATWAVES ON RED ABALONE, HALIOTIS RUFESCENS, ACROSS MULTIPLE SIZE CLASSES (YOUTUBE)

† Chiachi, A.E.; Silbiger, N.J.; Barnas, D.M.

California State University, Northridge

Anthropogenic warming has caused extreme heatwaves to become more frequent and severe, leading to negative impacts on many coastal fisheries. Due to the high cost of maintaining seawater conditions, aquaculture facilities, including those for red abalone, often pump water directly offshore, leaving their stock susceptible to natural environmental fluctuations. To improve production efficiency, aquaculturists use size-class grading to organize abalone for market sale, leaving a gap in knowledge of understanding how marine heatwaves will affect the metabolic rates of different size classes of red abalone. Here, we tested the effect of a realistic heatwave on the survivorship, growth, respiration, and consumption rates of 30, 60, and 90 mm abalone from the Cultured Abalone in Goleta, CA. Our results show that marine heatwaves reduced survivorship in all size classes. Abalone that experienced a heatwave also generally grew more slowly and had lower respiration rates than abalone in ambient conditions. Consumption rates were negatively correlated with respiration rates, but there was no treatment effect. Overall, our results highlight that marine heatwaves can negatively impact abalone metabolic rates and that the magnitude of the effect varies by size class. This research can help aquaculturists strategize best management for red abalone fisheries and conservation practices in the future.

Influence of southern CA’s marine reserve network on the spiny lobster fishery (YOUTUBE)

Lenihan, H.S.

Bren School-UCSB

Marine Protected Areas (MPAs) are designed to enhance biodiversity and ecosystem services. Some MPAs are also established to benefit fisheries through increased egg and larval production, or the spillover of mobile juveniles and adults. Whether spillover influences fishery landings depend on the population status and movement patterns of target species both inside and outside of MPAs, as well as the status of the fishery and behavior of the fleet. We tested whether an increase in the lobster population inside newly established MPAs influenced local catch, fishing effort, and catch-per-unit-effort (CPUE) within the sustainable California spiny lobster fishery. We found greater build-up of lobsters within MPAs relative to unprotected areas, and greater increases in fishing effort and total lobster catch, but not CPUE, in fishing zones containing MPAs vs. those without MPAs. Our results indicate regional differences in the influence of MPAs on fishery performance.

NON-LINEAR EFFECTS OF HEATWAVE TEMPERATURES ON TREMATODE PARASITE TRANSMISSION (YOUTUBE)

MacLeod, C.D.; Harley, C.

University of British Columbia

Parasitic infection dynamics are sensitive to temperature fluctuations, with warmer conditions often correlated with increased parasite production and transmission success, especially within and between ectotherm hosts. Global warming is predicted to cause increases in both production and transmission, although supporting empirical evidence has thus far been reported only in lab-based studies. The heatwave experienced in the Pacific Northwest in 2021 provided an excellent opportunity to study the effects of temperature on parasite transmission at an unprecedented scale in naturally occurring host-parasite populations. We surveyed 34 coastal sites around British Columbia and found evidence of an optimal temperature for the transmission of the trematode parasite Maritrema gratiosum into Balanus glandula hosts. At sites where temperatures and tide cycles exposed barnacles to “moderate” heatwave temperatures, large numbers of small, presumably “young of the year”, trematode cysts were found in infected hosts, while at sites that received the highest temperatures, there were no small cysts, despite high infection loads of larger, fully developed cysts,
suggesting that the preceding life stage to the cysts could not complete transmission in the most extreme temperatures. Our findings shed light on in situ transmission infection dynamics in the context of future climatic conditions and describes a novel host-parasite model system that may be used to investigate many ecological questions regarding the role of infection in a warming marine environment.

**MICROCLIMATE PREDICTS KELP FOREST EXTINCTION IN THE FACE OF DIRECT AND INDIRECT MARINE HEATWAVE EFFECTS (YOUTUBE)**

Starko, S.
Neufeld, C.J.
Gendall, L.M.
Timmer, B.
Campbell, L.
Yakimishyn, J.
Druehl, L.D.
Baum, J.K

1- University of Victoria 2- Bamfield Marine Sciences Centre 3- Pacific Rim National Park Reserve

Climate change-amplified warming events (i.e., heatwaves) threaten the persistence of many ecosystems, through both direct physiological effects and indirect effects arising from altered species interactions. These events have spatially variable impacts due largely to the broad and fine-scale environmental variation over which they are superimposed. Yet, most studies have focused on the role that very broad environmental gradients (e.g., across latitudes) play in predicting responses to climatic events, ignoring the likely role of local environmental variation. Along temperate coastlines, kelp forests are especially vulnerable to climate change, with marine heatwaves among their greatest threats. Fine-scale environmental conditions may be especially important in mediating heatwave responses for kelp forests since much of their distribution is along complex fjord-laden coastlines that experience wide variation in local conditions. Synthesizing historical data and modern resurveys, we show that the combined direct and indirect effects of an unprecedented heatwave caused extensive losses of two canopy-forming kelp species far from their respective range edges. Kelp forests were largely extirpated from warm microclimates found inshore but persisted in cool habitats, either towards the outer coast or at depths exceeding the thermocline. The efficacy of deeper habitats as thermal refugia was, however, strongly limited by the presence of herbivorous urchins, whose influence had increased through a trophic cascade indirectly amplified by the heatwave.

**NO-TAKE MARINE PROTECTED AREAS CAN ENHANCE FISH AND FISHERY OUTCOMES OF KELP FOREST RESTORATION (YOUTUBE)**

Hopf, J.K.
Caselle, J.E.
White, J.E.

1- Oregon State University 2- UC Santa Barbara

The accelerating loss of kelp forest habitats globally threatens the sustainability of critical coastal ecosystem services like fisheries. In response, kelp forest restoration is being increasingly considered, and used, as a management action. A key challenge in this approach is identifying when and where limited restoration resources will be most beneficial. Here we consider the relative benefits that restoring kelp habitat within marine protected areas (MPAs) might bring to coastal fish populations and their associated fisheries. Using a single-species population model where kelp habitat loss reduces recruit survival, we show that undertaking restoration inside MPAs can at least double the fish biomass benefits, but that this may come at a small cost to yields, especially if the fishery is well managed. However, if the system experiences increased pressures (i.e., from fishing or increased habitat loss), then restoring inside MPAs benefits both fish and fisheries. We also found that when the MPA protects species that have a large positive influence on kelp habitat growth (e.g., through removing herbivores such as urchins), restoring outside MPAs is marginally more beneficial for these species, provided habitat recovery is primarily limited by ecosystem processes (e.g., herbivory). In either case, our simulations suggest that positive outcomes from successful restoration actions may be difficult to detect in time-series data because of complex transient dynamics. This work provides context for setting management goals and social expectations around the ecosystem service.

Session 22: General Session 10

* indicates presenting author, † indicates eligibility for Best Student Paper Award

**EVALUATING THE IMPACT OF A MARINE HEATWAVE ON RESOURCE AVAILABILITY, DIET, GROWTH, AND REPRODUCTION IN A TEMPERATE REEF FISH (YOUTUBE)**

Chubak, B.R.
Steele, M.A.
California sheephead are among the most ecologically important fish on temperate reefs in California and Mexico, yet little is known about their reproductive ecology. Environmental factors can affect reproductive success in fish populations in a variety of ways, including by affecting diet. The goal of this study was to determine if any differences in reproduction among populations of California sheephead (Semicossyphus pulcher) were related to differences in diets during a marine heatwave. We measured the prey availability, diet composition, batch fecundity, and growth rates of California sheephead on three large reefs within the Southern California Bight from 2012 to 2018, which included a large marine heatwave. Growth rates, reproductive output, diet, and prey availability differed among the years, implying that the heatwave may have affected prey availability and diet, which might have affected reproductive output and growth. Specifically, during the heatwave, when prey items of low dietary value were consumed, reproduction output decreased. Understanding how changes to kelp forest habitat impact reproductive output and growth can aid in future management efforts of economically and ecologically important species of fish, especially with warming events becoming more common and more intense.

**TURNING UP THE HEAT: HOW DO PARENTAL TEMPERATURE ENVIRONMENTS EFFECT THE QUALITY OF PROGENY IN A FISHED MARINE INVERTEBRATE?** (YOUTUBE)

† Xochitl S. Clare*; Gretchen E. Hofmann

*University of California, Santa Barbara

There is a limited understanding on how oncoming marine heatwaves (MHWs) will impact economically important shellfish species at vulnerable early life stages. It is essential to consider how parental thermal history influences progeny success under temperatures to be experienced in future MHWs. To explore the effects of MHW exposure on an emerging California kelp forest fisheries species, the Kellet’s whelk (Kelletia kelletii), we acclimated adult whelks at MHW and non-MHW temperatures (15 degrees Celsius versus 20 degrees Celsius) and assessed the quality of their offspring produced at these two experimental conditions. Egg capsules remained in tanks as they were laid, and progeny were assessed for thermotolerance and condition at four early stages: embryo, trochophore, veliger, and hatchling. A generalized linear mixed-effects model was used to generate larval thermal tolerances and assessments of body condition (LT50, AB50) calculated using a logistic regression for temperatures. Overall, the MHW temperature had an impact on maternal response (e.g., whelks in the 20 degrees Celsius treatment showed delayed egg laying in comparison to whelks conditioned at 15 degrees Celsius). This presentation will share insights on how parentalexperiencesinfluencedthermotoleranceofearlystages, and further, how upper thermal limitsofearly stages compare to temperatures currently observed in the kelp forest. This work highlights the significance in contextualizing eco-physiology findings within abiotic and biotic environmental data for economically important ecosystems.

**SMALL-SCALE SUBSTRATUM ORIENTATION AND THERMAL DIFFERENCES DRIVE MORTALITY AND DIVERSITY PATTERNS IN BARNACLE BEDS** (YOUTUBE)

† Hesketh, A.V.*; Harley, C.D.G.

*University of British Columbia, Department of Zoology

The summer of 2021 demonstrated the catastrophic potential for heat waves acting on communities, intertidal and otherwise. Here, we report on the results of opportunistic surveys and a manipulative shading experiment, which attempt to explain factors underlying patterns in the mortality of the thatched barnacle, Semibalanus cariosus, in British Columbia, Canada and understand its role in facilitating biodiversity. Differences in maximum air temperatures did not explain barnacle mortality patterns across sites. However, differences within sites were largely explained by substratum orientation, with higher mortality occurring when the angle of incoming sunlight during low tide was more direct. Experimentally shaded barnacles had significantly greater survival than unshaded barnacles. The invertebrate communities associated with dead barnacle beds were not necessarily less diverse than those of live beds but were significantly different in terms of species identity; dead beds were dominated by desiccation-tolerant organisms such as littorine snails and high-intertidal limpets, while live beds contained organisms like sea cucumbers, whelks, and anemones. Unshaded
treatments where barnacles were removed had lower species richness, and recruitment was significantly lower than in shaded removal plots, indicating that heat waves both remove *S. cariosus* from shores and prevent the establishment of nascent beds. This study highlights the limitations of foundation species in buffering intertidal communities from climate change, particularly when stochasticity is at play.

**WHO ARE WE? HIGHLIGHTING NUANCES IN ASIAN AMERICAN EXPERIENCES IN ECOLOGY AND EVOLUTION (YOUTUBE)**

Lee, A.1*; de Leon Sanchez, E. E. *; Nguyen, K.; Akiona, A; Chang, C.; Chaudhary, V. B.; Cheng, S.; Johson, S. Arizona State University; Kahanamoku, S.; Segui, L.; Tanner, R.

1- Purdue University 2- University of California, Santa Barbara 3- University of South Florida 4- University of California San Diego Scripps Institution of Oceanography 5- University of Washington 6- Dartmouth College 7- University of Michigan, Center for Research on Learning and Teaching 8- Arizona State University 9- University of California, Berkeley 10- N/A 11- Chapman University

Following an uptick in violent incidents fueled by COVID-19, anti-Asian racism has been brought to the forefront of attention in the US. Thus, there is a need to both discuss and address how issues of racism toward the Asian American community manifest in our own academic communities. We examine anti-Asian racism in Ecology and Evolutionary Biology (EEB) and provide recommendations on how individuals, departments, and professional societies can combat it. Notably, Anti-Asian racism does not always manifest in the same ways across groups. An important step to disrupting the different ways that racism manifests in EEB is to change the practices our discipline uses to collect and present demographic data. Disaggregation of demographic data reveals important nuances about the experiences of marginalization within the Asian American community. Additionally, funding for Asian American scientists in EEB at all career stages is limited by the systematic failure to recognize differences in representation among Asian American ethnicities. Professional societies and funding agencies should disaggregate demographic data by ethnic group to facilitate the recognition of specific minoritized Asian American groups. We also urge our EEB colleagues to recognize that there is heterogeneity in the Asian American experience both inside and outside of academia, and that our varied histories impact our visibility and participation in the scientific community.
**Poster Presentations**

* indicates presenting author, † indicates eligibility for Best Student Paper Award

**LATITUINAL VARIATION IN NEARSHORE ROCKFISH SPECIES’ LENGTH-FREQUENCIES ALONG THE CALIFORNIA COAST**


Moss Landing Marine Laboratories

The body size of a species often varies along a latitudinal gradient. This statement is based on an eco-geographic axiom, Bergmann’s rule, which states that individuals of a species will have larger body sizes in climates of colder temperatures with nutrient-dense waters, and smaller body sizes under warmer conditions. We used four years of data from the California Collaborative Fisheries Research Program (CCFRP) to determine if the patterns laid out by this well-tested rule would be consistent for species with different life history traits. The CCFRP uses standardized hook and line fishing techniques to survey nearshore fishes in MPAs from northern to southern California. Thus, the fish we used for our study were all caught in waters less than 50 m deep, in nearshore rock and kelp habitats. We compared the total lengths of 6 rockfish species at 12 different MPAs along the California coast, spanning from Cape Mendocino State Marine Reserve to South La Jolla State Marine Reserve. Olive rockfish and Copper rockfish, both macro-invertivores, exhibited the strongest length-frequency variations along a latitudinal gradient, with larger fish appearing in northern sampling locations and smaller fish appearing in southern sampling locations. Even though the planktivore Blue rockfish was the most frequently caught species, there was almost no variation in mean total lengths among the sampling sites, regardless of the latitudinal position. Our findings highlight the fact that variations in life history traits may affect the patterns of length-frequency changes with latitude.

**THE IMPLICATIONS OF RARITY FOR REEFS CORALS: SCIENTIFIC NEEDS AND OUTREACH OPPORTUNITIES**

Didden, C*; Frank, K 2; Girard, J 3; Edmunds, P.J. 4

1- Viewpoint School 2- Campbell Hall School 3- U of Rhode Island 4- CSUN

The coral reef crisis has brought large declines in coral abundance, as recorded through coral cover. Common ecological tools of photoquadrats and line-intercept techniques have demonstrated that many reefs now are covered by a trivial amount of coral, but with so little coral remaining, the study of coral ecology is becoming an analysis of rare organisms. For these taxa, the compelling questions differ from those of relevance to common organisms, and they require approaches that address rarity. Rare organisms are time consuming to enumerate, but the ease of identifying novel organisms lends the task to crowd sourcing and outreach by academic institutions. The fringing reefs of St. John, US Virgin Islands, reflect the challenges of rarity, as coral cover is <5%, corals are widely separated, and now Stony Coral Tissue Loss Disease is killing the remaining colonies. In 2021, we designed sampling using Cartesian coordinates and GPS to locate rare corals in plots accessible by diving or snorkeling by participants with a range of scientific training. For Dendrogyra cylindrus, Pseudodiploria spp. and Diploria labyrinthiformis, mean densities ranged from 0 to 1.1 colonies/100 m2, and for Siderastrea siderea, mean density was 61.6 colonies/100 m2. For the 3 rarest taxa, nearest neighboring conspecifics were so far apart that fertilization of their gametes is unlikely, thus rendering them ecological ghosts. University-school partnerships provide the potential to expand the time-consuming analyses that now are necessary to evaluate the future of rare corals.

**Concurrent climate induced range movement in herbivore and primary producer**

† Cortese, M.R.*; Freestone, A.L.

Temple University

As global oceans get warmer, species are moving poleward to reduce thermal stress. As species ranges change, so do their interaction networks leading to trophic mismatches, and creating the potential for concurrent movement of dependent species. This study aims to understand how species interactions alter range movements to better predict community dynamics under global change. We address these complex dynamics in the Eastern Pacific kelp forest ecosystem by modeling herbivory interactions in a Species Distribution Modeling framework. Giant kelp (Macrocystis pyrifera) forms the foundation of the forest, with purple sea
urchins (*Strongylocentrotus purpuratus*) as the dominant herbivore with strong preference for *M. pyrifera*.

Using Maxent, we first modeled the distribution of giant kelp under current day and climate change scenarios. We then modeled the purple urchin’s current day and projected future distribution using only environmental variables and then a second time with kelp presence included as a predictor variable. Model results demonstrated an expansion in giant kelp range under climate change. When included in range models of purple urchin, kelp moderated projected urchin contraction indicating the importance of integrating species interactions into modeling frameworks, particularly when planning for global change. Jackknife analysis showed a high variable importance for kelp and temperature as predictor variables in urchin models, further demonstrating the importance of primary producer availability for herbivore species distribution.

**TRILLIONS OF STARS IN THE UNIVERSE, BUT HOW MANY SEA STARS ARE IN THE OCEAN?**

Siegel, P.J.*; Haupt, A.J.

*Department of Marine Science, California State University, Monterey Bay*

Understanding species population dynamics is crucial to make predictions about changes due to climate change and create effective conservation policies. *Pisaster ochraceus*, an intertidal sea star, is a keystone predator that controls the population of mussels and ultimately increases the diversity of the primary substrate holders within the intertidal. Within the last decade, *P. ochraceus* populations, along with other sea star species populations, have declined dramatically due to sea star wasting syndrome, a serious disease that causes body and muscle deterioration. While this disease is still very persistent within sea star species, some recovery is occurring. During summer 2021 we surveyed 6 sites to assess spatial variation in recovery. At each site we conducted transects and quadrats to determine abundances of sea stars. It is clear that recovery is not even across sites. This will serve as a baseline to inform future research on spatial variation of sea star recovery along the Monterey Peninsula and what site characteristics influence recovery. Understanding spatial variation in recovery will help inform restoration efforts for these important key stone species.

**Detecting the Effects of Rising Atmospheric Carbon Dioxide on Ocean Carbon Dioxide in the California Current System using Satellite**

† Anderson, Danielle*; Palacios, Sherry L.

*CSU Monterey Bay*

Title: Detecting the Effects of Rising Atmospheric Carbon Dioxide on Ocean Carbon Dioxide in the California Current System using Satellite Remote Sensing Observations Authors: Danielle Anderson 1, Sherry L. Palacios 2 Affiliations: College of Science, California State University Monterey Bay

Climate change has had record breaking effects on many biological systems and chemical processes within our oceans. Phytoplankton are important to the health and functionality of marine environments because they regulate ocean biogeochemistry acidification, act as primary producers, and are a food source for oceanic and non-oceanic food chains. There are many variables in our ocean which are impacted by climate change, and also influence phytoplankton activity. By detecting changing patterns of those variables such as sea-surface temperature (SST), chlorophyll-a (CHL), salinity, and partial pressure of carbon dioxide (pCO2), we can understand the impact of climate change on phytoplankton. This study focuses on creating an empirical algorithm to detect the partial pressure of carbon dioxide in seawater using satellite remote sensing observations. To build our new empirical algorithm, we used in situ observations from the NOAA Pacific Marine Environmental Laboratory California Current Ecosystem moorings. The in situ model related SST and CHL to pCO2 using multiple linear regression. This model was then applied to remote sensing observations from the AQUA-MODIS sensor. The model predicted trends in pCO2, but uncertainty estimates suggested a need to refine the mo

**Spatial and Temporal Variability in Nutritional Physiology of Pyropia sp.**

† Elliott, M.S.*

*Moss Landing Marine Labs*

The red alga *Pyropia sp.* is ubiquitous throughout the intertidal of California, serving as a rich source of nutrients for herbivores with high % tissue nitrogen and protein concentration. However, the California
coast has variable oceanic nutrient concentrations and photoperiod impacted by time and space. The purpose of this study is to illustrate how time, space, and environmental conditions affect % tissue nitrogen and protein concentration in Pyropia. Pyropia sp. was collected each month between February 2021 to October 2021 at five sites between Bodega Bay, CA and Santa Barbara, CA. Satellite data was used to model the correlation between % tissue nitrogen, protein concentration, and environmental conditions. A outdoor closed tank system was used to grow Pyropia for ten day trials under specific nutrient species (NO$_3^-$ and NH$_4^+$) and nutrient concentration (0m, 5m, 15m, 50m) to see if nutrient concentration significantly effects % tissue nitrogen and protein concentration. The % tissue nitrogen of Pyropia sp. had a positive correlation with sites farther north (P = 0.003). Tissue nitrogen of Pyropia was significantly higher during months of high upwelling intensity, and colder sea surface temperature (P = 0.001). Pyropia sp. grown in high nutrient concentration tanks had the highest % tissue nitrogen, however growth rate of Pyropia was not significantly different due to nutrient species or concentration. The % tissue nitrogen in Pyropia was found to be significantly different due to nutrient concentration.

GUT CONTENT AND FATTY ACID ANALYSES REVEAL TROPHIC ROLE OF CTENOPHORE PLEUROBRACHIA BACHEI IN NORTHERN CALIFORNIA CURRENT† Masterman, J.A.$^1$; Galloway, A.W.E. $^1$; Sponaugle, S. $^2$; Cowen, R.K. $^2$; Sutherland, K.R. $^1$

1- Oregon Institute of Marine Biology 2- Hatfield Marine Science Center

Gelatinous zooplankton are important yet understudied components in pelagic food webs. The ctenophore Pleurobrachia spp. is known to influence the food webs of productive marine coastal regions, but the prey and predators of P. bachei in the Northern California Current (NCC) remain unknown. To explore the trophic role of this ctenophore in the NCC, samples of P. bachei, and their potential prey and predators were collected from cross-shelf transects off Newport, OR and Trinidad, CA in the winters and summers of 2018 and 2019. Gut content analyses revealed P. bachei in the NCC primarily fed on copepods and invertebrate eggs, and predated minimally on chaetognaths, appendicularians, and crustaceans. P. bachei predation patterns varied significantly with season (Permanova p=0.016); compared to summer samples, winter samples exhibited both a greater variety of prey items and heavier predation on later life stages of copepods. Fatty acid analyses indicated P. bachei predate on calanoid copepods and have a relatively high percentage of essential fatty acids (18:3$
_
3$, 20:5$
_
3$, and 22:6$
_
3$) at 43±2% of total fatty acid content. These results suggest that in the NCC P. bachei acts as a competitor to other secondary consumers, including larvae of commercially important fishes that also rely on calanoid copepods and invertebrate larvae as prey. P. bachei may also act as an important source of essential fatty acids within the NCC, further highlighting the need to include this gelatinous zooplankter in pelagic food web models.

THE STALKED BARNACLE POLLICEPES POLLICEPES: RECOVERY OF EXPLOITED AREAS† Sousa, A.$^1$; Jacinto, D. $^2$; Mateus, D. $^2$; Neves, F. $^2$; Fernandes, J. N. $^2$; Castro, J. J. $^3$; Seabra, M. I. $^2$; Penteado, N. $^2$; Leandro, S. M. $^4$; Maia, S. $^5$; Silva, T. $^2$; Cruz, T. $^3$

1- 1 MARE – Marine and Environmental Sciences Centre, Laboratório de Ciências do Mar, Universidade de Évora, Sines, Portugal 2- 1 MARE – Marine and Environmental Sciences Centre, Polytechnic of Leiria, Peniche, Portugal 3- 1 MARE – Marine and Environmental Sciences Centre, Laboratório de Ciências do Mar, Universidade de Évora, Sines, Portugal; 3 Departamento de Biologia, Escola de Ciências e Tecnologia, Universidade de Évora, Portugal 4- 4. MARE – Marine and Environmental Sciences Centre, ESTM, Polytechnic of Leiria, Peniche, Portugal 5- 2. MARE – Marine and Environmental Sciences Centre, Polytechnic of Leiria, Peniche, Portugal

The stalked barnacle Pollicipes pollicipes occurs in exposed rocky shores from Brittany (France) to Dakar (Senegal). It is an important economic resource in Portugal and Spain, where it is heavily exploited by scraping of clumps of individuals from the substratum. The recovery of exploited areas is poorly studied/understood. In the opinion of several fishermen, the recovery of exploited areas depends on the way the exploitation is carried out. According to them, recovery is greater when exploitation within barnacle groups is directed only to large barnacles being hindered when the whole group is exploited. The aim of this study was to describe the evolution of the recovery of exploited areas. A manipulative experiment was set
up at Cabo de Sines (SW Portugal) in the summer of 2020. Two tidal levels were considered (mid and low shore) and in each tidal level two treatments were applied (non-exploited clumps of barnacles versus clumps of barnacles where exploitation was simulated). Sampling size varied from 3 to 10. Each replicate consisted of a 15x15 cm quadrat placed on a clump of \textit{P. pollicipes}. All replicates were photographed approximately quarterly for one year and the images analyzed with QGIS software. Response variables evaluated were the percentage cover of \textit{P. pollicipes} on the 15x15 cm quadrat over time, and the area of an identified \textit{P. pollicipes} clump inside each quadrat over time. Recovery was analyzed by comparing the cover and area of \textit{P. pollicipes} at the start of the experiment and throughout the year in both treatments and tidal levels.

Quantifying Coastal Erosion with Drones: A Cheap, Effective Tool for Remote Monitoring
† Anderson, G.D.\textsuperscript{1*}; Anderson, S.S.\textsuperscript{2}; Patsch, K.\textsuperscript{2}
\textsuperscript{1-} California Polytechnic State University at San Luis Obispo \textsuperscript{2-} California State University Channel Islands

Background rates of coastal erosion are predicted to rise over the coming decades with sea level rise and more frequent and intense erosive weather systems. Our annual inventorying of southern California coastal geomorphology is helping to define the current rates of sea cliff calving. Our drone-based mapping, coupled with high-resolution structure from motion topographic reconstructions, allows accurate estimates of volume loss for both long-term estimates of coastline change and acute needs for emergency response. Drone-based geomorphic monitoring is cost effective and insulated from local constraints such as road closures and pandemic restrictions.

NOT SO SHELLFISH AFTER ALL: HOW NATIVE OYSTERS (\textit{OSTRELLA LURIDA}) MAY AID EELGRASS (\textit{ZOSTERA MARINA}) RESTORATION BY N FILTRATION
† Emery, M.E.\textsuperscript{1*}; K.E. Nichols \textsuperscript{1}; K.D. Nichols \textsuperscript{2}; D. Zacherl \textsuperscript{1}
\textsuperscript{1-} CSU Fullerton \textsuperscript{2-} Orange County Coastkeeper

Eelgrass (\textit{Zostera marina}) is a foundation species in coastal waters that provide vital ecosystem services from habitat provision to trophic support. However, populations have declined globally at alarming rates including within Upper Newport Bay (UNB), CA. A multi-habitat restoration approach with native oysters (\textit{Ostrea lurida}) may be key to promoting more successful eelgrass restoration. Oysters may increase nitrogenous nutrients in sediment porewater for uptake by eelgrass by mediating nitrogen transfer via filter-feeding and depositing nitrogenous waste. Resource managers are concerned about the efficacy of co-restoration with oysters due to potential negative interactions with eelgrass, a protected species. Little research has been conducted to date to address the efficacy of restoring these species together. In summers 2019 and 2021, we collected eelgrass shoots and pore-water samples from three restored sites within UNB, each with eelgrass restored alone versus eelgrass restored adjacent to oysters. We measured leaf and rhizome growth rates, above and below ground dry weight, and pore-water NH4+ and NO3- concentrations. We analyzed these response metrics relative to distance from and density of oyster beds using co-variogram models. Preliminary results indicated positive associations at closer distances but only at some sites, with no significant associations at others. Given this generally neutral relationship, project managers should consider restoring both species in combination because each species can return unique ecosystem functions.

DETERMINING POTENTIAL HABITAT OF A GLOBALLY INVASIVE KELP, \textit{UNDARIA PINNATIFIDA}, BY EXAMINING THERMAL TOLERANCES OF GAMETOPHYTES
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The potential for invasion following species introduction is one of the greatest threats to global biodiversity costing the United States upwards of $120 billion annually. Marine systems are at risk given the rise in global oceanic transport and exchange of resources with seaweed species being particularly good invaders due to their multi-phasic life cycle, high fecundity, and stress tolerance. \textit{Undaria pinnatifida} is described as a globally invasive seaweed species that is declared by the IUCN as one of the 100 most invasive species on the planet with established populations in nearly 16 countries including the United States, specifically within California. Despite nearly half a century of global spread, there is little information on the phenology or factors influencing the success of this seaweed in the United States. Here our goals were to use existing
data to estimate potential invadable habitat across the west coast of the United States. Our preliminary results suggest that sea surface temperature across the California coast from March through August may allow for Undaria reproduction.

LATITUDINAL VARIATION IN JAW MORPHOLOGY OF THE PURPLE SEA URCHIN, STRONGYLOCENTROTUS PURPURATUS, ALONG THE NORTHERN CALIFORNIA COA
† Stein, S.M. 1*; Murphy-Cannella, M. 2; Zuno, D.A. 1; Maxwell, B.R. 1; Elsmore, K. 3; deVries, M.S. 1

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Purple sea urchins, Strongylocentrotus purpuratus, are voracious consumers of kelp in ecosystems worldwide. They were previously thought to exhibit phenotypic plasticity in jaw morphology, lengthening their jaws relative to test diameter in times of low macroalgal abundance to increase the efficiency of scraping algae from hard substrates. We tested the hypothesis that jaw length to test diameter ratios (relative jaw length) would be higher in urchin barrens than in sites with abundant kelp. Urchins were collected from three sites in Northern California: Noyo Harbor, Caspar Cove and Albion (listed from north to south) in March and June, 2021. Urchin tests were measured and gonad weights were recorded. One demi-pyramid from each individual was photographed and measured for length. Relative jaw length ratios were calculated. Data from March when there was some kelp cover at Noyo Harbor and Albion but not Caspar show a trend of decreasing relative jaw lengths moving from north to south (i.e. highest values in Noyo, Kruskal-Wallace, p-value < 0.01). This pattern was also exhibited in June but the trend was not significant (p-value = 0.06), even though kelp density increased at Noyo and Albion. Unlike in March, gonad weight followed a latitudinal gradient with increased weights from north to south in June (p-value < 0.01). These results suggest that relative jaw lengths are more related to geographic variation than they are to kelp abundance and lead to questions of whether increased relative jaw lengths improve feeding efficiency in these Northern California populations.

USING OTOLITH GEOCHEMISTRY TO REVEAL THE ORIGINS AND RUN-TYPE OF JUVENILE CHINOOK SALMON PREYED UPON BY ENDANGERED CA LEAST TERNS
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1- University of California Davis 2- University of California Santa Cruz 3- Point Blue Conservation Science

Wild Chinook Salmon (Oncorhynchus tshawytscha) in California have experienced sharp declines in population size due to an array of anthropogenic pressures. Chinook Salmon smolts (juveniles that are migrating to the ocean) are prey for numerous native species in California, including the endangered California Least Tern (Sterna antillarum browni). A large breeding colony of California Least Terns occurs in the San Francisco Estuary at Alameda Point each summer and coincides with smolt outmigration. Between 2007 to 2018, Point Blue Conservation Science has collected and maintained an archive of fish specimens, including juvenile Chinook Salmon, dropped near the California Least Tern colony by foraging parents returning to the colony. Here, we use otolith (ear stone) geochemistry to reconstruct the maternal run-type (winter, spring, or fall-run), origin (hatchery or wild), and natal watershed of 200 smolts that were captured and dropped by California Least Terns over the course of several breeding seasons across both wet and dry (drought) conditions. Our results highlight and detail a relatively understudied trophic pathway involving juvenile salmon and an endangered coastal avian piscivore. Detailing such interactions among managed species, and across years with different climates, can help improve future management strategies and, ultimately, the recovery of listed species.

How seasonal thermal variation within the intertidal zone affects the thermal escape behavior and body condition of Petrolisthes c
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San Francisco State University

Temperature influences population distribution, body size, metabolism, making it a driving ecological and evolutionary factor. Due to climate change global temperatures are rising. For example, sea surface tem-
peratures are expected to increase by 1.8-3.5 °C by the end of the century and extreme climate events are predicted to become more intense and frequent in the future. My research seeks to understand how thermal seasonal changes can influence the behavior and physiology of Porcelain crabs living in the intertidal zone. This project encompasses two objectives to investigate the interactions between seasonal thermal variation, microclimate variation, thermal behavior, and body condition (BC). I assessed how temperature avoidance behaviors vary across fine-scale seasonal thermal variation and BC using a behavioral assay, video analysis, and motion tracking software. I investigated relationships between atmospheric temperature data and under-rock temperature to generate the ability to make predictive inferences of crab BC, thermal avoidance, and temperature fluctuations in the intertidal zone from weather data. I hypothesized that thermal avoidance varies across seasonal thermal variation and during extreme heat events, that thermal avoidance is related to BC, and that aspects of weather data can be used to reliably predict microclimate temperatures in the intertidal zone. Overall, my research will contribute to the knowledge of how marine invertebrates are affected by climate change, and the physiological limits constraining their ability to adapt to changing temperatures.

USING A HISTORICAL ECOLOGY APPROACH TO DESCRIBE ALGAL COMMUNITY CHANGE: NEUSHUL REVISITED
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Shifting baselines across decadal time scales make it difficult to detect and understand long-term changes in macroalgal communities. Historical data can provide the basis for these long-term comparisons, but is sparse for benthic systems. This study aims to use one rare comprehensive survey of benthic macroalgae in the San Juan Islands, Washington published by Michael Neushul in 1967 as a historical baseline for surveys of the benthic macroalgal community along the Brown Island shoreline. By repeating dive surveys along three of Neushul’s original transects, using a DropCam to take still photos along ten transects, and conducting snorkel surveys along the shoreline edge of three transects, we make comparisons between the state of Brown Island algal communities in 1962/63’ and July of 2021. We found that the presence of the canopy forming kelp Nereocystis luetkeana, which was observed in Neushul’s original study, has reduced almost to nothing. Snorkel surveys along the shoreline and one dive survey showed the presence of the invasive brown seaweed Sargassum muticum that was not present in 1967. In general, subcanopy kelps and understory macroalgae are not a focus of recent studies of kelp distribution changes. This study provides a unique description of understory macroalgae communities with historical context. Further study of this area and a more thorough repetition of Nueshul’s original transects can provide deeper insight into long-term trends and the current state of the Brown Island macroalgal community.

CHANGES IN ROCKY SUBTIDAL COMMUNITIES ON THE OREGON COAST FOLLOWING THE OUTBREAK OF SEA STAR WASTING DISEASE
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Linfield University

In 2014, the Oregon Coast was hit with Sea Star Wasting Disease (SSWD). This epidemic is estimated to have killed up to 90% of sea star populations on the Oregon coast. As a keystone species, sea stars such as *Pisaster ochraceus* are known to impact the abundance of other organisms in the benthic communities that sea stars thrive in. To examine changes in communities, we sampled at Netarts Bay and Yaquina Bay, Oregon. Tissue samples of tunicate and sponges were collected in 2011 prior to SSWD and then in 2021. These samples were analyzed using high throughput sequencing to determine the composition of their microbiomes. Video transects were taken at both sites from 2011 to 2021 to monitor how species density changed over time. Percent cover of several groups of benthic organisms was calculated using CPCe 4.1 software. When compared to each other, there were significant differences between the population sizes over time of algae vs. barnacles, barnacles vs. zoanthids, sea cucumbers vs. sea stars, sponges vs. tunicates, and tunicate vs. sea stars. Over the years 2011 to 2021 the Oregon coast saw changes in population density, most drastically between the years 2013 to 2014, and 2020 to 2021. It is likely that these changes were influenced by the changes in sea star population due to SSWD.
TYPHOON EFFECTS ON A “WEEDY” CORAL: POST TYPHOON CORAL RECOVERY-
POSITIVE IMPACTS FOR PREVIOUSLY OUTCOMPETED SPECIES
† Arizmendi, K, A 1*; Paddack, M, J 2; Rumal, J, Jr 3; Crane, N, L 4; Nelson, P 5; Roberts, M 6; Bernardi, G 6

1- One People One Reef, UCSC, SBCC 2- One People One Reef, SBCC 3- One People One Reef 4- One People One Reef, Cabrillo College 5- One People One Reef, California Department of Water Resources 6- One People One Reef, UCSC

One People One Reef has been monitoring coral reefs on Ulithi Atoll, Federated States of Micronesia since 2012. We documented the spatial distribution and size structure of an “outbreak” coral- an undescribed species of Montipora. These Montipora-dominated reefs are lower in diversity & abundance of both corals and reef fishes, and some evidence suggests that this particular Montipora sp is out-competing other corals and expanding its presence locally. In 2015 super-typhoon Maysak had a significant affect on these Montipora dominated coral reef ecosystems, but had significantly less damage on other coral genera. Recovery trajectories of reefs around the atoll appear to differ, with Montipora sp. beginning to once again overtake reefs and spread. However other hard coral genera like Acropora and Pocillopora have benefited from the affects of typhoon Maysak and may be recovering in previous Montipora space. At one site that was previously Montipora dominated, however, we observed recovery of other species of corals such as Acropora rather than Montipora sp. This reverse in coral dominance may be related to changes in fishing practices on this reef. Here we evaluate recovery trajectories among reefs along the atoll of MogMog. We examine whether Acropora or other hard corals are now providing greater structural complexity at this one reef site and explore whether this impacts reef fishes.

SEASONAL IMPACTS ON NATIVE AND NON-NATIVE SETTLEMENT AND SUCCES-
SION ON ARTIFICIAL REEFS
† Frantz, T. 1*; Walter, R.P. 1; Merkel, K. 2; Zacherl, D.Z. 1

1- CSU Fullerton 2- Merkel and Associates, Inc.

Anthropogenic impacts such as coastal infrastructure, transglobal shipping, and aquaculture have the potential to negatively impact native community composition through a loss of habitat or introduction of non-native species. Simultaneously, resource managers are implementing multi-function projects to protect necessary infrastructure while aiming to restore native biodiversity. Although artificial reefs are often successful in providing habitat for a wide array of fish and invertebrates, they often favor non-native species and thus may not be adequate surrogates for naturally occurring substrate. At Navy Base Point Loma in San Diego Bay, a multi-purposed habitat designated the FoISH (Fish, eelgrass, Subtidal, Intertidal Habitat) artificial reef was deployed to restore an eroded beach. As a proxy for new reef space, recruitment tile sets have been deployed at three depths (-5, -10, and -20 ft. MLLW) and four seasons. To characterize seasonal priority settlement and resulting community structures, each tile set consists of six replicates removed at 3-, 6-, and 12-month temporal intervals post-deployment. We use comparisons of percent cover and density of identified species, species richness, and community composition to test the hypothesis that the seasonal availability and depth of newly deployed substrate will yield distinct final community compositions by impacting the priority settlement and successional sequence of recruiting invertebrates and macroalgae. Preliminary results indicate that season, depth, and tile side have significant effects on community structure.

EVIDENCE FOR YEAR-ROUND OCCUPANCY BY GRAY WHALES (Eschrichtius robustus) ON THE NORTHERN SONOMA AND SOUTHERN MENDOCINO COASTS
Mercer, Scott 1*; Shari 2

1- Mendonoma Whale and Seal Study 2- Mendonoma Gray Whale Photo Identification Project

Since January 2014, we have been conducting an annual census of migrating North Pacific gray whales (Eschrichtius robustus ) as they travel from Northern feeding grounds to their breeding and calving grounds in the warm lagoons of Mexico’s Baja peninsula and their return migration to the Bering, Chukchi, and Beaufort Seas. In addition, we conduct daily surveys of all cetaceans observed and record their presence and behaviors. Our observation area along the northern California coast ranges from Jenner in Sonoma County north to Fort Bragg in Mendocino County with the majority of surveys taking place at the Point Arena Lighthouse peninsula. In 2016 we began noticing juvenile gray whales foraging in our study area. In the
past two years we have begun photo documenting these juveniles as well as adult gray whales foraging in the area. When appropriate we have contributed photographs of individual grays to research groups such as Cascadia Research Collective in Washington and to Happywhale.com which uses photos to identify and track individual whales. We believe this represents an expansion of the Pacific Coast Feeding Group, a subset of the population known to feed through the summer and fall from Northern California to Southeast Alaska. We plan to collect and share further photo documentation of these grays whales to support our hypothesis.

**URCHINS: BENTHIC CONSUMERS TURNED MICROPLASTIC PRODUCERS**

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1- Oregon Institute of Marine Biology; University of California, Santa Barbara 2- Oregon Institute of Marine Biology

In the Pacific Northwest, populations of the purple sea urchin *Strongylocentrotus purpuratus* have increased in recent years, leading to overgrazed kelp forests. By 2025, the ocean is expected to contain 250 million tons of plastic. Because of their concurrent increase, we may expect to see increased interactions between urchins and plastics, and their consequential outcomes. Previous studies have reported urchin consumption of plastic and production of microplastics (pieces <5 mm in length). Here, we ask if urchins will consume polypropylene rope, if they consume bio-fouled rope at a higher rate than unfouled rope, and if they produce microplastics after consuming the rope. We conditioned (aged) rope in a seatable with constant seawater flow and provided urchins with three rope treatments in a feeding trial: new rope, three-week aged rope, and one-year aged rope. Urchins exposed to the new rope did not cause any visible damage to the rope. Urchins exposed to three-week rope left some fraying, and urchins exposed to one-year old rope left intense fraying. There were significantly more plastics produced (\(z=2.7, p=0.023\)) by the three-week and old (\(z=2.7, p=0.019\)) rope urchins than produced by the control. As expected, the urchins did consume the rope and had a preference for the biofouled pieces. These results show that urchins exposed to bio-fouled plastics produced more microplastics than those exposed to new plastics, highlighting a potential role for urchins in exacerbating plastic pollution.

**DYNAMICS OF SELECTION AND GENE FLOW IN PACIFIC PURPLE SEA URCHIN POPULATIONS ALONG THE CALIFORNIA COAST**

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1- University of California, Davis 2- California State University Los Angeles

The Pacific purple sea urchin (*Strongylocentrotus purpuratus*) is an iconic species on the California coast. S. purpuratus are the dominant consumers of giant kelp and have the ability to create urchin barrens which greatly impact regional patterns of biodiversity. However, we have an incomplete understanding of population genomics and the extent of local adaptation in purple urchins, knowledge of which would assist in conservation efforts. Local adaptation for pH has been documented at a few genomic sites between urchins in southern versus northern California, but is coupled with high levels of gene flow. We present whole genome sequencing for 120 individuals sampled at fine spatial scales from the California coast. We documented population genetic structure between northern and southern populations. Fst outliers between populations indicate selection is acting on a subset of the genome. Additionally, we found candidate SNPs associated with mean chlorophyll, mean attenuation, and pH, further supporting the idea of selection across the environmental mosaic that exists within coastal California. Our data reveals that although gene flow is high in this system, local adaptation may still play a role in structuring genomic variation in purple urchins across the California coast.

**THE DECLINE IN NUMBERS OF GRAY WHALES (Eschrichtius robustus) COUNTED ALONG THE MENDOCINO COAST IN NORTHERN CALIFORNIA IN 2020-20**

Mercer, Theresa*; Mercer, Scott

Mendonoma Whale and Seal Study

Since 2014 we have conducted a count of gray whales migrating south from northern feeding grounds primarily in the Arctic to breeding grounds in the lagoons of Baja Mexico and again as they return to their feeding
grounds to the north. An Unusual Mortality Event first seen in May of 2019 has resulted in 487 known gray whale deaths as of 5 August 2021. The actual number of dead gray whales is likely significantly higher. As a result, the National Oceanic and Atmospheric Administration has reduced its estimate of 26,930 gray whales in 2016, to 20,580 in 2019/2020, a reduction of about 23.7%. We believe our numbers from the 2020-2021 season in comparison to the two previous counts show that decline. For this study, each season is defined as December 1 through April 30. In 2018/2019 we counted 905 southbound grays and 754 northbound grays. In 2019/2020 we counted 735 southbound gray whales and 887 northbound grays. This season, 2020/2021 we recorded 702 southbound and 604 northbound during that time frame. That is a reduction of 203 less southbound than in 2018/2019, and 33 less 2019/2020. For our northbound count, we had 150 less than 2019 and 283 less than in 2020. The effort in terms of observation days and the numbers of hours of observation each day has remained consistent each season.

THE INTERMEDIATE PREDATOR’S EFFECT ON STRONGYLOCENTROTUS PURPURATUS AND MACROCYSTIS PYRIFERA DURING SEA STAR WASTING DISEASE
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Santa Catalina School

Giant kelp (Macrocystis pyrifera) is a foundation species along the Central California coast, and provides habitat for a diverse community. This community includes the purple urchin (Strongylocentrotus purpuratus), which are typically present in low numbers. In 2013 Sea Star Wasting Disease (SSWD) decimated the starfish (Pycnopodia helianthoides) population, which may have been acting as an important mesopredator for the urchins. Starting in 2015, urchin barrens began rapidly appearing replacing the kelp forest. Pathogenic destruction of starfish populations along the coastline possibly caused cascading trophic events leading to the urchin barrens which would eliminate much of the kelp forest and the habitat they provided. To test the role of starfish prediction on kelp canopy persistence, I analyzed the population sizes of these three organisms (kelp, starfish, and urchins) using data provided by PISCO surveys between 1999 and 2019. I found slight but significant correlations in changes of these populations of the species over this timeperiod underscoring the importance of starfish predation as a regulator of subtidal communities.

RESTORATION TRAJECTORIES OF BENTHIC INVERTEBRATE COMMUNITIES IN NEIGHBORING WETLANDS IN SOUTHERN CALIFORNIA
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Wetland habitats are valuable ecosystems that provide a range of ecosystem services such as reducing erosion, lessening impacts of storms and floods, filtering pollution, and sequestering carbon. Despite this importance, anthropogenic activities have decreased the amount of wetland habitat along California’s coast over time. Therefore, efforts to restore these wetland habits are increasingly important and require greater understanding of restoration trajectories and timelines. This research focuses on the restoration trajectories of several salt marshes in southern California including a tidally muted lagoon (Colorado Lagoon), a ponded marsh in the middle of a relatively intact salt marsh (Seal Beach Wildlife Refuge), and a small marsh restoration (Jack Dunster Marine Reserve). We found that the older restoration sites have higher benthic infaunal invertebrate abundance, richness, and diversity than the more depauperate short-term restoration site (Colorado Lagoon). This project increases understanding of benthic macroinvertebrate communities in different stages of restoration in highly urbanized, densely populated areas and may become a key component in deciding plans for future wetland restoration projects.

NORTHERN ELEPHANT SEAL (MIROUNGA ANGUSTIROSTRIS) COW SITE FI- DELITY AND WEANLING MOVEMENT AT POINT REYES NATIONAL SEASHORE
† Edgard Morazan1*; Caliope Gallagher 1; Camryn Figueroa 1; Doreen Gurrola 1; Sarah Codde 2
1- Dominican University of California 2- Point Reyes National Seashore

Dominican University of California (DUC) collaborated with the National Park Service by conducting surveys of northern elephant seals (Mirounga angustirostris) at Point Reyes National Seashore (PRNS). Park researchers began monitoring this colony and tagging weaned pups in the 1980s, as the colony was re-
established. Data were collected to determine the total number of seals at each haul-out site, gender, age, and tag resights. Surveyed locations include Drakes Beach, Kenneth Patrick Visitor Center, Lifeboat Station and Fish Docks. Total seal count within each age class was recorded. Additionally, data collected from the Park Service from the 2017-2021 breeding seasons were analyzed. Weanling and cow site fidelity was determined among these years. Thirteen surveys were conducted, with the highest count being in April consisting of 542 immatures and weanlings. Drakes Beach consistently had the highest count. Of cows resighted in multiple years, 72% had site fidelity, pupping at the same beach in subsequent years. Whereas 28% of the cows had low site fidelity pupping at different beaches in PRNS in subsequent years. There appears to be site fidelity among cows with some local movement among beaches. Weanlings appear to move among the local beaches before heading out for the season. From the years of consistent data collecting, it has brought an abundance of data, which has served as a vital tool to determine site fidelity and movement among individuals.

VIDEO ANALYSIS OF BAITE D TRAPS AS FISH AGGREGATING DEVICES (FADS) IN TWO HABITAT TYPES WITHIN LOS PENASQUITOS LAGOON, CA.

Trainer, Sivanna*; Beirzychudek, Abigail; Dr. Talley, Drew

University of San Diego

Baited traps are widely used to characterize fish communities in coastal environments, but the accuracy of this representation is uncertain. One criticism is that traps have the potential to misrepresent community composition by attracting organisms from outside the environment being observed. Using video analysis, we studied the effects of baited minnow traps as fish aggregating devices in unvegetated sand (“bare bottom”) and oyster reef environments within Los Penasquitos Lagoon, CA. Bare Bottom is a less complex habitat compared to Oyster Reef that is more complex with rocks and shells as shelters and food availability. GoPro® cameras were deployed at each location twice a week from October-December 2020 once with a baited trap and second without a trap. Video footage was analyzed for both species richness and the maximum number of individual species recorded at one time (MaxN). Results showed no significant difference in species richness between trap and no trap in either habitat type. MaxN species for the trap videos in Bare Bottom were higher on average compared to the no trap videos, while there was no difference in MaxN between trap/no trap in Oyster Reef videos. These results suggest that traps in Bare Bottom may attract species and give an inaccurate representation of diversity in that area. Conversely, traps in more complex environments (Oyster Reef) may not affect fish behavior. This information can be important for future coastal ecology research, choosing proper techniques/methods, and understanding if/how results are being misrepresented.

A SYNTHESIS OF BIOLOGICAL RESPONSES TO SUBMARINE GROUNDWATER DISCHARGE ON CORAL REEFS

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Submarine groundwater discharge (SGD), the outflow of terrestrial or recirculated seawater into a coastal region, is known to harbor distinct biogeochemical signatures, often being a source of variable salinity, temperature, pH, nutrients, carbonate chemistry, and microbes. Despite being a globally significant influence on coastal ecosystems, popularity of SGD research has only gained traction in the last 50 years, primarily focused on hydrology and biogeochemistry. Impacts on coastal biology, particularly within coral reef habitats, have been relatively overlooked. Here, we review the extent of biological impacts of SGD on coral ecosystems. Specifically, we examined the effects of SGD on community composition, physiology, recruitment, disease, and metabolism. Due to the biogeochemical variability of SGD, where each source exhibits a unique signature, we found that biological impacts to coral reefs also varied. Rates of production and calcification changed relative to unaffected reef due to the properties and strength of the SGD signal. Meanwhile, more consistent effects included decreased benthic community diversity and stony coral biomass, and increased macroalgal biomass near strong SGD influence. SGD is a ubiquitous source of coastal environmental impact, yet to our knowledge, this is the first review to examine the biological effects of SGD on coral reefs in depth. Given the rapid increase in global climate change and anthropogenic impacts to coral reefs, understanding foundational impacts on these ecosystems is paramount to managing future ecological shifts.
Did the implementation of marine protected areas affect southern California’s commercial spiny lobster fishery?
Gonzales, K.E.*; Shen, C.; Wertz, S.P.

CDFW

The California spiny lobster (Panulirus interruptus) is an ecologically and economically valuable species in southern California. On January 1, 2012, some areas historically open to lobster fishing closed due to the establishment of marine protected areas (MPAs) in California state waters between the US-Mexico border and Point Conception. Fisheries management was not an explicit goal of California’s MPAs, and there was concern that fishing closures might negatively impact commercial fisheries. We used commercial lobster landings receipts to examine temporal and spatial patterns of catch (# of lobsters landed), effort (# of traps pulled), and catch per unit effort (CPUE) in commercial fishing blocks (10 nm x 10 nm) in southern California in the time periods before (2003-11) and after (2012-20) MPA implementation. Although nearly 15% of state waters in the region were closed to commercial lobster fishing, total catch and effort were not significantly different between the pre- and post-MPA periods. However, the spatial distribution of lobster fishing shifted after MPA implementation. Mean catch and effort were lowest in blocks without MPAs in the post-MPA period. Mean CPUE was, overall, higher in the pre-MPA period, but has been on a small but significant upward trend since MPA implementation due to a downward trend in effort and an uptrend in catch. Based on these data, it appears that fishing closures due to MPA implementation have not adversely affected average catch or CPUE of the commercial lobster fishery.

DEVELOPMENT OF CRYSTALLINE REGIONS IN CHITON LARVAE
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Chiton larvae develop a pair of ellipsoidal regions containing many tiny crystals (1-2um); they remain well past metamorphosis and increase in abundance. These crystalline regions correspond to the locations of the paired larval kidneys (protonephridia), but fixing larvae with buffered reagents (formalin or ethanol) dissolved the crystals, hindering ultrastructural studies. To determine if these crystals result from kidney function, we raised larvae in lowered salinity and reduced-calcium artificial seawater in separate functional studies. Both girdle spicules (made of CaCO$_3$) and the crystalline regions formed later in larvae grown in lowered salinity compared to those in full strength SW. Reduced calcium and artificial seawater prevented gridle spicules from forming and delayed the formation of crystalline regions compared to natural SW controls. These results do not allow us to determine if crystals are a result of kidney function. Solubility in ethanol and delayed formation in reduced calcium suggests crystals have an organic component. We also observed the crystalline regions post-settlement and formation of the shell valves for the first time. After shell valve formation, crystalline regions changed shape, qualitatively matching the location and change in shape of the protonephridia in juvenile chitons. Future research should focus on reliable methods to preserve the crystalline regions in specimens and develop a method to accurately measure the crystalline region to determine fine changes of their development in response to different stressors.

EFFECT OF KELP FOREST AND URCHIN BARREN MICROHABITATS ON PURPLE SEA URCHIN (S. PURPURATUS) GONAD INDEX
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1- Boston University 2- UC Santa Cruz 3- Oregon State University

The kelp forest urchin barren dynamic is a constant shift between two stable states as habitats can transition from kelp forest to urchin barren continuously due to purple sea urchin (Strongylocentrotus purpuratus) grazing. Urchin grazing rates can have an effect on food availability which in turn affects the gonad condition of an urchin. We investigated the microhabitats within the kelp forest urchin barren habitat gradient to examine the gonad condition of sampled urchins by measuring the gonadosomatic index (GSI) of the urchins. Five different microhabitat conditions were sampled (kelp forest, urchin barren, articulated coralline algae, Desmarestia, and red algae) and gonad wet-weight was used to calculate the GSI of the urchins. The results of the study showed that the GSI within urchins sampled from the kelp forest, Desmarestia, and red
algae conditions were significantly higher than the GSI within urchins sampled from the urchin barren and articulated coralline algae conditions. However, there was no significant difference between the kelp forest, Desmarestia, and red algae conditions, and likewise with the urchin barren and articulated coralline algae conditions. The effect of the microhabitats on gonad condition creates an additional understanding on the food availability in kelp forest and urchin barren habitats while showing the distribution of urchins based on gonad condition across the microhabitats.

PHYLOGEOGRAPHIC ANALYSIS OF AN ECOLOGICALLY IMPORTANT CALANOID SPECIES IN THE NORTH PACIFIC
† Bauer, K.K.1*; Barreto, F.S.1; Sam Zeman 2

The calanoid copepod, Calanus marshallae, is a numerically dominant and ecologically vital member of the pelagic marine food web of the North Pacific. Because of its massive populations from the Bering Sea through the California Current, traditional views presume unrestricted dispersal and high gene flow between geographically distant populations. However, seasonal oceanographic barriers and complex life histories were recently shown to be associated with unexpected genetic lineages in other cosmopolitan calanoid species in both the Arctic and Atlantic oceans. Here, we investigate the phylogeography and population connectivity of C. marshallae along five different latitudes between Crescent City, California, and La Push, Washington. For this, we sequenced the mitochondrial cytochrome oxidase I gene from multiple individuals per locality and performed analyses of genetic diversity and divergence within and among sampling locations to test for the presence of phylogeographic breaks. This work is the first to examine population genetic patterns in this important and abundant species off the Northeastern Pacific, and it serves as a pilot project to inform further comparative genomics on populations C. marshallae to better understand the effects of oceanographic barriers and environmental heterogeneity on the evolution of holoplankton in the North Pacific.

MUSSEL BED AREA TRACKS SEA STAR ABUNDANCE THROUGH SEA STAR WASTING DISEASE OUTBREAK
Gorum, O.A1*; Vogel, C.M1; Detrait, A.O1; Micheli, F.2

The Rocky Intertidal is a diverse ecosystem, home to over 1,000 species of invertebrates and algae, making it an important subject for scientific study and monitoring. A keystone predator in the intertidal is the Pisaster Sea Star. Since 2013, Sea Star Wasting Disease has impacted starfish populations from Alaska to Baja, California-causing near-extirpation of some species. Here, we use mussel bed surface area as a measurement of sea star population disease and recovery. We found an increase in surface area over the course of the last decade. We also compared sea surface temperature and wave force from local NOAA buoys to examine physical factors that may impact mussel bed surface areas. Changes in mussel bed area did not clearly reflect changes in the physical environment (SST or wave height). However, changes in mussel bed area were associated with changes in Pisaster population. These data support rocky intertidal keystone predation models and may provide a useful way to assess post-disease dynamics in starfish populations using mussel beds responses.

PHYSIOLOGICAL DIFFERENCES BETWEEN PALEOZOIC AND MODERN FAUNAS: A POSSIBLE EXPLANATION FOR HISTORICAL EXTINCTION SELECTIVITY TRENDS
Noll,C.P.*; Sperling,E.A.; Duncan,M.I.; Marquez,J.A.; Stockey,R.G.

The Earth has experienced several major extinction events in its history with differential selectivity between clades, yet the mechanisms that drive this selection are unresolved. Extinction intensity also has decreased over the Phanerozoic Era. Recently, Payne et al., 2020 suggested that physiological changes in organisms through time is one possibility that could explain these trends in extinction. To test this hypothesis, this project explores if physiological traits related to temperature-dependent hypoxia tolerance vary by higher taxa or by evolutionary ‘Faunas.’ To do this, we first obtained geo-referenced occurrence points for extant invertebrate species by digitizing their distribution maps in the Beneath Pacific Tides: Subtidal Invertebrates
of the West Coast field guide and matched these occurrences to temperature and oxygen values at the ocean floor obtained from the World Ocean Atlas database. We used the lowest levels of oxygen occupied by a species as an indicator of its hypoxia tolerance and used the slope of a quantile regression at the 5th percentile of inhabited oxygen values across temperatures to quantify the temperature sensitivity of this hypoxia tolerance ($E_0$). After dividing the data into Paleozoic and Modern Faunas, we find that extant representatives of the Paleozoic Fauna are more hypoxia tolerant but are also more temperature sensitive. The Paleozoic Fauna’s high temperature sensitivity compared to that of the Modern Fauna provides a possible explanation for the observed decrease in extinction intensity over the Phanerozoic.

THE NORTHERN RANGE LIMIT OF THE EASTERN PACIFIC MARINE GASTROPOD TEGULA EISENI IS INFORMED BY RECENT INATURALIST RECORDS

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The Western Banded Tegula, *Tegula eiseni* Jordan, 1936, is a familiar member of Southern California’s marine rocky intertidal gastropod fauna. Its modern species range is considered as spanning from Magdalen Bay, Baja, Mexico to Los Angeles County, California, USA. Although records exist of *T. eiseni* as far north as Monterey, California, as well as the Channel Islands, it is published (e.g. in Between Pacific Tides), as rare north of coastal Los Angeles County. To assess this rarity and/or any changes in its northern range limit through time, we examined *T. eiseni* museum collection records and iNaturalist observations. We found few museum records of *T. eiseni* from north of Los Angeles County, but more than 30 research-grade iNaturalist observations since 2015 of *T. eiseni* in Ventura and Santa Barbara counties, both north of Los Angeles County. The presence of *T. eiseni* north of Los Angeles is evaluated and discussed as a geographic range extension or unusual northern occurrence. The value and utility of publicly collected and available species occurrence data (e.g. iNaturalist observations) for understanding species range changes and abundance through time and space are also presented.

VIRTUAL REALITY SCIENTIFIC DIVING IN THE CLASSROOM

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A group of Cal Poly student scientific SCUBA divers generated underwater virtual reality (VR) videography of scientific methods in marine ecology research, including benthic transect surveys for quantifying the population densities of marine invertebrates. We accomplished this using a 360° spherical underwater video camera (From Dr. Whites lab). We filmed at the Cal Poly Pier and in Montana de Oro using the Cal Poly boat, the Richards. Using this video footage, we created a VR scientific diving experience for 7th-grade students. We partnered with a local teacher at Laguna Middle School for testing the VR experience using Chromebooks and/or wear re-usable, affordable VR browsers (recycled phones inserted into Google Cardboard headsets). As they watch our video, the students will not only experience SCUBA diving but also conduct scientific methods themselves. For example, they will “swim” a transect and quantify the abundance of benthic invertebrates they see, such as sea urchins. Furthermore, we developed a lesson plan that guides the students in analyzing their data after the VR experience, comparing their results with other students and classes that also conducted transect surveys. Collectively, this educational experience will support 7th-grade students achieve the NGSS Performance Expectation MS-LS2-1, “Ecosystems: Interactions, Energy, and Dynamics” (NGSS 2013). By increasing understanding and appreciation for life in the ocean, we can inspire students to think about climate change and how their actions affect the animals that they “studied” through our videos.

SEX RATIOS IN A COMMON SEA ANEMONE ON THE OREGON COAST

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The sea anemone *Anthopleura elegantissima* reproduces both asexually and sexually. Asexual reproduction routinely occurs with adult animals dividing to generate clonal aggregates complete with differentiated roles within the colony. The anemones also reproduce sexually via broadcast spawning with external fertili-
tion. Therefore, proximity to mates would lead to increased reproductive success. However, some previous studies, with relatively low sample sizes, calculated skewed sex ratios. For example, Ford (1964) found a sex ratio of approximately ~2 females to 1 male (n=22 clones). Ayre and Grosberg (2005) found an almost equal ratio with males being slightly favored at one site. To determine if these biased ratios are an artifact of low sampling, we conducted a survey of multiple clones (n=50) at an Oregon coast (Seal Rock) study site. Colonies were sampled in the months of July, August, and September 2021 with 3 individuals from each clone taken. Animals were dissected and sexed to find the overall sex ratio of these colonies; the ratio of sexes per boulder and the gonadal status were also measured to determine if adjacent colonies were more likely to be the same or different sexes. In the July sampling, 58% (n=87/150) of the total anemones sexed were male, 30% were female, and 10% were unknown. The August sampling found a more even mix, with 26% female, 22% male, and 52% unknown. The change in sex ratio may be caused by the emptying of the gonads in spawning events, causing them to be harder to sex in the absence of developed gonads.

**ESTIMATING INFECTION LEVELS OF EELGRASS (ZOSTERA MARINA) BY LABYRINTHULA ZOSTERAE IN NORTH-CENTRAL CALIFORNIA**

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Seagrasses are an important and challenged foundation species found around the globe, with their population health threatened by increased disease risk related to climate change. Seagrass wasting disease, caused by the net-slime mold *Labyrinthula zosterae*, is currently present at low levels in north-central California. Climate change may cause an increase in disease intensity for a native species of seagrass (*Zostera marina*, eelgrass) in north-central California due to increases in salinity and temperature. These environmental conditions are favorable for the mold, *L. zosterae*. Our goal is to determine the levels of disease intensity in seven key eelgrass beds in San Francisco Bay (SFB) and Point Reyes National Seashore (PRNS). To achieve this, we calculated the percent of lesion coverage on selected eelgrass blades collected from seven key eelgrass beds using two different methods that were thought to provide moderate and high estimates. We expected to see a higher prevalence and intensity of seagrass wasting disease in beds in the urbanized SFB compared to the protected Drakes Estero and Tomales Bay in PRNS, due to a higher stress environment for the eelgrass in SFB. However, preliminary results showed a higher percentage of lesion coverage in Drakes Estero and Richardson Bay, two of the larger sampled beds. Understanding the current state of seagrass wasting disease in north-central California is valuable knowledge for managing eelgrass beds to limit the impacts of the disease.

**DETERMINING THE SPATIAL DISTRIBUTION FOR NORTHWEST ATLANTIC LEATHERBACKS AND POTENTIAL IMPACTS OF VESSEL TRAFFIC ON THEIR MOVEMENT**

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Northwest Atlantic leatherback turtles (*Dermochelys coriacea*) are in decline and listed as endangered. They are particularly vulnerable to interactions with human activities, such as fishing and vessel traffic during the internesting period (between nesting bouts) when turtles are concentrated in nearshore habitats. For our study, female leatherbacks (n=6) were tracked using satellite tags. We used spatial statistics, a switching state-space model (SSSM) and home-range estimates to determine the distribution of the internesting leatherbacks off Limón Province, Costa Rica at 6-hour intervals. We then analyzed vessel traffic in the region using their automatic identification system (AIS) and determined if it had an impact on the turtles’ behavior. We analyzed vessel traffic exposure and speed and compared it to the turtle movement characteristics; speed, turning angle, and absolute angle. We found that the turtles were mostly concentrated directly off the nesting beach, and their turning angles were significantly associated with vessel exposure and speed (Cochran-Mantel-Haenszel test, p<0.01). Our results can help to inform managers and future studies about potential vessel traffic impacts on this endangered species and encourage practical mitigation if necessary,
such as regulations on vessel speed.

**PISMO CLAMS (TIVELA STULTORUM) EXHIBIT PROMISING ESCAPE BURROWING POTENTIAL FOLLOWING EXCESSIVE SEDIMENT BURIAL**


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Sandy beach habitats are naturally dynamic and prone to sediment disturbance, for which many infaunal organisms are well-adapted. Beaches along developed coastlines are often also disturbed by beach nourishment programs, which produce large-scale burials and generally negative ecological consequences. For infaunal bivalves, post-burial survival can require “escape burrowing” to reestablish an appropriate position in relation to the sand-water interface. The Pismo clam (*Tivela stultorum*) is an iconic California bivalve species which inhabits many beaches where nourishment activity is common, with unknown consequences for the species. Here, we report on the escape burrowing potential of Pismo clams in laboratory trials where individual clams (*n*=65, length range 10-71 mm) were buried in sediment to depths of 10, 20, 40, and 60 cm. Clams of all sizes exhibited strong escape burrowing potential, with nearly 97% of individuals reestablishing their natural burrowing depth within 72 hours of burial. We also observed escape burrowing rates as fast as 30 cm hr\(^{-1}\) (and 30 body lengths hr\(^{-1}\)), with a mean of 10.7 (±9.1 SD) cm hr\(^{-1}\). Although in situ escape burrowing performance and the effects of other environmental factors have yet to be determined, these results indicate that Pismo clams may also be resilient to natural or anthropogenic burial disturbances in the wild.

**THE EFFECTS OF PHRAGMITES AUSTRALIS INVASION STRESS ON COMMUNITY FUNCTION**

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A history of human modifications of Suisun Marsh, CA has altered the ecological community of tidal wetlands, creating environmental instability and promoting invasive species in novel ecosystems. Invasive species impose stress on native species through resource competition. One invasive plant in Suisun Marsh is *Phragmites australis*. We examined the effects of Phragmites on the tidal marsh ecosystem by comparing community function between invaded and native habitats in January and June of 2021. We conducted plant and bird surveys, recorded continuous abiotic conditions, and collected invertebrate samples across benthic, pelagic, and terrestrial zones. We also conducted a lab experiment raising amphipods under abiotic conditions typical of Phragmites and native habitats. Species abundance and size were larger in the summer, regardless of vegetation type. Phragmites plots provide an environment that is cooler and less variable than native plots, which can reach temperatures that are too warm for invertebrates during heat waves. While invertebrate biodiversity is higher in native plots, amphipods raised in the laboratory in Phragmites abiotic conditions grew larger and had better survival. Amphipods are a food resource for fishes, and may be more resilient in Phragmites stands. Phragmites eradication is prioritized but expensive. Our data suggest potential benefits Phragmites may provide as a climate change refuge for key food resources, despite reductions in biodiversity. We must consider community function when enacting invasion control measures in tidal wetlands.

**Population genetics of Mytilus californianus in Baja California, Mexico**

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*Mytilus californianus* is a mussel species that distributes from Alaska, USA, to Baja California, Mexico, along the west coast of North America. Previous studies have concluded that this species is genetically homogenous, probably due to its long pelagic phase and potential for dispersal. However, climatic changes in the past 15 years, such as storms, hypoxia events, and extreme heatwaves, have resulted in changes in abundance and distribution of a great diversity of species, affecting the local adaptation and reducing the genetic variability. These changes could be particularly interesting at the species range limit. Here, we explored the genetic diversity of *Mytilus californianus* in three sites spanning the Baja California peninsula:
El Zeppelin in the north, Punta Baja in the center, and Faro San José at the southern limit of distribution, using the mitochondrial gene cytochrome oxidase subunit I (COI). We collected tissue samples from mantle or gill from 86 individuals. We performed PCR amplification using COI standard primers developed for marine invertebrates. The PCR products were sequenced, and the sequences were cleaned and aligned. We estimated the genetic diversity in these three populations and evaluated the level of population structure. This study represents a genetic evaluation of the susceptibility of coastal species to drastic ecological changes and provides insights into species adaptation to future climate change scenarios.

**A COMPARISON OF MULTIPLE METHODS TO MEASURE PURPLE SEA URCHIN POPULATION DENSITIES WITHIN THE MONTEREY PENINSULA INTERTIDAL**

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The purple sea urchin plays an important role in controlling algal populations within marine environments and acts as a valuable food source for a multitude of predators. An increase in purple sea urchin populations in subtidal habitats have been well documented, but their population behavior in the intertidal is less well understood. Monitoring these populations is difficult when different methods of data collection are used across research programs. Methods to combine data collected with different methodologies are needed to use to examine large spatial and temporal scales. During the summer of 2021, we collected density data for purple sea urchin populations in the intertidal across multiple sites within the Monterey Peninsula using two different methods: transects and quadrats. Our goal was to understand population densities within the intertidal and how they have changed since a previously unpublished study from 2002. Density estimates from 20m x 2m transects were consistently lower than density estimates from our 1m². Our data underscores the difficulty joining data from disparate sources and our next steps are to create an equation or algorithm to appropriately compare the different data types. This will improve our ability to better understand how the populations of purple sea urchins are changing within the intertidal of the Monterey Peninsula by leveraging many datasets.

**DIGITIZATION OF THE UCSB HERBARIUM'S SEAWEED COLLECTION PROVIDES VITAL DATA TO BETTER UNDERSTAND THE CHANGING MARINE ENVIRONMENT.**

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The macroalgae collection of the UC Santa Barbara (UCSB) Herbarium has been utilized as a resource by students and researchers at UCSB. In order to increase the scientific value of the collection, we have initiated a digitization project to add to a growing data set being assembled by a consortium of seaweed herbaria. Collectively, these data can be used to address questions of changing climate, ocean currents, invasive species, and biodiversity along the Pacific Coast of North America. Our IMLS-funded digitization project is focused on digitizing ca. 10,000 specimens in our Pacific Coast of North America collection. Our digital data are currently available on two Symbiota-based web portals: The Consortium of California Herbaria 2 and the Macroalgal Herbarium Portal. Our data are also aggregated and shared worldwide through the Global Biodiversity Information Facility (GBIF). Our digitization project is not only creating high-quality public data, but also is providing ample opportunities for learning about algae and the activities associated with curation in a natural history museum. UCSB students, interns, and volunteers gain hands-on experience with our collections, seaweed identification, and phycological special events. The history and scientific insight that herbaria can tell argue for the importance of their preservation and for the continued need for new field collections. Reimagining these collections to present them to a wider audience increases the kinds of voices in science and the types of questions that can be asked about our changing world.

**EXAMINING THE EFFECTS OF THE 2014 - 2015 MARINE HEATWAVE ON FISH COMMUNITY COMPOSITION ALONG THE CENTRAL CALIFORNIA COAST**

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Marine heatwaves (MHWs) are increasing in intensity and frequency across the world and these events have been shown to impact the diversity and composition of fish communities. California experienced a heatwave from 2014-2015, where ocean temperature anomalies were persistently elevated along the entire U.S. West Coast by up to 6 degrees C. Our study seeks to understand the impact of the 2014-2015 MHW on rocky reef fish diversity and community composition along the central California coast. We utilized hook-and-line survey data collected by the California Collaborative Fisheries Research Program to examine fish species diversity and community composition inside and outside four Marine Protected Areas (MPAs) along central California before, during, and after the 2014-2015 MHW. Across the entire region there was a drastic decline in evenness and Shannon-Weiner diversity following the MHW both inside MPAs and in associated reference sites (REFs). We also found that there was a shift in community composition following the MHW due to changes in relative abundance of Blue Rockfish, Olive Rockfish, Black Rockfish and Gopher Rockfish in both MPAs and REFs. In more recent years, there is evidence that diversity and evenness are recovering more rapidly inside the MPAs than REFs. Our results suggest MPAs may not mitigate short-term effects of climatic disturbance events, such as MHWs, but may contribute to the long-term resiliency of marine fish communities.

THE TEMPORAL RELATIONSHIP BETWEEN SEA SURFACE TEMPERATURE ANOMALIES AND KELP COVERAGE AROUND THE MONTEREY PENINSULA.
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One of the effects of increased marine temperature observed in recent history is the increase in frequency and intensity of marine heatwaves, which have adverse effects on foundation species and, therefore, entire ecosystems. The marine heat wave of 2014 - 2016 caused devastation of kelp forest ecosystems along the west coast of the US. Previous losses of kelp canopies into sea urchin barrens in Southern California have resulted in over 90% of the species found in the areas becoming less abundant, 36% of which were heavily reliant on the forests for survival. There is ample evidence that kelp forests are negatively impacted by rising temperatures, but to what extent and the exact temporal relationship is yet to be fully understood. To better understand this relationship, we used Landsat 8 OLI imaging to survey Kelp bed areas around the Monterey Peninsula by Calculating the Normalized Difference Vegetation Index and their respective Sea Surface Temperatures which were spatially separated and viewed for anomalies and variance in R from 2013-2020. My analysis thus far found that kelp canopy extent decreased 85% from 2013-2020. There was a time lag observed of 18 months from the temperature anomalies and large losses of kelp. Better understanding of the relationship of rising temperatures and foundation species is necessary to make predictions of climate change effects on ecosystems to inform management of these ecological and economically important habitats.

EFFECTS OF PERSISTENT ORGANIC POLLUTANTS AND CLIMATE CHANGE ON ATLANTIC KILLIFISH EMBRYO METABOLISM
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The Atlantic killifish (Fundulus heteroclitus) is remarkably tolerant to a variety of environmental stressors including pollution and temperature. Although Atlantic killifish are tolerant of extreme conditions, this tolerance may come at a survival cost that includes effects on metabolic rate. I investigated the physiological cost of adaptive tolerance to persistent organic pollutants by focusing on the metabolic rate of F1 embryonic Atlantic killifish incubated in increasing water temperatures at constant intervals. Using two pollution-tolerant (Newark and New Bedford) and three pollution-sensitive (Scorton Creek, Jerusalem, and Sandy Hook) populations exposed to ambient and elevated water temperatures, I measured embryo metabolism and developmental rate were measured using a micro-respirometry system. I found a significant effect of adaptive tolerance on how oxygen consumption rate varied with water temperature, with tolerant populations showing little variance in oxygen consumption rate among temperatures. There was also a significant difference in developmental rate between temperature treatments for each site. The differences in metabolic rate suggest a cost of adaptation to pollution exposure, however the discrepancy between the development and metabolic changes found in this study indicate there are other important factors and mechanisms that
are influencing how Atlantic killifish embryos respond to interacting environmental stressors, which have important conservation implications for this species and its varying habitats.

**Kelp gametophyte recruitment in articulated coralline algae of the San Juan Islands**

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Kelp species dominate Salish Sea rocky intertidal communities, overlapping with a diverse array of articulated coralline algae species. Though little is known about the gametophyte phase of kelp's obligate biphasic life cycle, it has been suggested that articulated coralline algae play a role in kelp gametophyte recruitment. To test whether Hedophyllum sessile gametophytes settle in the genicula of three articulated coralline algae species, we collected coralline algae samples near H. sessile populations and examined their genicula under a microscope. Those assumed to contain brown algal gametophytes underwent DNA extraction and PCR. Samples that amplified with kelp-specific primers were sequenced but results were inconclusive. We complemented our field study with a tank experiment to investigate Alaria marginata spore settlement. One week after spore release into treatment jars, we extracted and analyzed DNA from coralline genicula to identify brown algae gametophytes. A control jar with A. marginata spores and no coralline algae contained developed sporophytes, while jars with coralline algae contained underdeveloped and dead spores. Kelp populations, threatened by rising ocean temperatures, cannot persist without reproductive success in both sporophyte and gametophyte phases. Kelp play an ecologically important role in coastal primary productivity, food webs, carbon sequestration, and have promising marine agronomic value. Future studies should investigate whether coralline algae release chemical toxins designed to inhibit kelp gametophyte recruitment in their genicula.

**EVOLUTION OF PAIRED APPENDAGES IN VERTEBRATES**

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Holocephalans exhibit appendages called pre-pelvic claspers (PPCs) that are located anterior to pelvic fins, while pelvic claspers (in male cartilaginous fishes) are pelvic fin modifications located posteriorly as modified metapterygia. Articulation points of the PPCs have not been evaluated and may represent modified pelvic fin structures if they articulate with the propterygium, or they may represent the only example of an independent third set of paired appendages in an extant taxon, if they articulate independent of the pelvic girdle. This would challenge the current paradigm that extant jawed vertebrates are constrained to two sets of paired appendages. To evaluate aspects of PPC morphology, articulation, and development; morphometric comparisons were made from male and female spotted ratfish (Hydrolagus colliei, Holocephala) from the collections of the California Academy of the Sciences, and from the Margaret Memorial Fish Collection at San Francisco State University. Both the PPCs and pelvic claspers increase in size until sexual maturity, relative to standard length, suggesting synchronous development. While females are larger than males, pelvic fins grow and develop faster in males compared to females, suggesting an advantage of larger and faster development. X-rays revealed that PPCs are not modified propterygia, nor do they articulate with the propterygium. They appear to articulate with the puboschiadic bar via the lateral pelvic process, suggesting that they may represent a third, independent set of paired appendages in extant holocephalans.

**LENGTH-WEIGHT RELATIONSHIP OF THE KELP FOREST GASTROPOD AND EMERGING FISHERIES SPECIES KELLET’S WHELK, KELLETIA KELLETII**

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The relationship between an individual fished species’ length and its weight (mass) represents essential biological information for supporting sustainable fisheries management and marine conservation. We determined the length–weight relationship for the marine shellfish and commercial fisheries species, Kellet’s whelk (Kelletia kelletii), a large predatory gastropod inhabiting subtidal kelp forests along the central and southern California, US, and Baja California, Mexico, coast. We measured 762 Kellet’s whelks across a range of sizes...
(16-155 mm length, 0.51-403.89 g weight) brought to port by commercial fishermen or that we collected using SCUBA from four regions across the species’ US geographic distribution – San Diego, Santa Barbara, the Channel Islands, and Monterey. We also dissected and determined the sex (male, female) of approximately two-thirds of the whelks. Model fitting revealed a cubic function to represent the length-weight relationship of the entire dataset with strong explanatory power. Neither whelk sex or collection region, independently or interactively, was found to significantly influence the length-weight relationship. The fitted model had slightly negative allometric growth, suggesting that shell length grows faster than the rate of increase of the organism’s weight. The information from this study can be used to inform management decisions for Kellet’s whelk conservation and fisheries harvest.

**Maximum seed yield and seed viability: two necessary considerations for a successful eelgrass seeding program**
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Restoring the seagrass, Zostera marina (eelgrass) is a high priority in the Puget Sound region of the Salish Sea. The harvesting and transplanting of adult plants is a common restoration technique, however, it is expensive, may not ensure genetic variation at the restoration site, and has the potential to damage the donor eelgrass populations. Another restoration technique through seed broadcasting has had success in the Chesapeake Bay region, where seeding programs work to restore areas where eelgrass has declined and even disappeared previously.

In this pilot project, we are experimenting with seed collection and various techniques to deliver seeds to our restoration site. The separate phases of seed dispersal include determining the time of the season to harvest in order to obtain maximum seed yield, and the appropriate season of dispersal to achieve restoration success. This current study focuses on the necessary evaluations needed to determine prime harvest time and correlating seed yield, as well as genetic variation of the donor population and data on spontaneous abortion between different collection periods. Based on field collections in summer 2020 and summer 2021 in the San Juan Archipelago, we found seed yield was 2.59 fold higher (independent two-tailed t5 = 3.8133, p=0.0125) in flowering shoots collected later in the summer rather than earlier in the season.

**GREAT LAKES BASIN AVIAN BIODIVERSITY AND CHANGES IN SPECIES-SAMPLING RELATIONSHIPS WITH WATERSHED POSITION**
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Species-sampling relationships (SSRs) that incorporate sampling effort are familiar models of how biodiversity will change when habitats are lost. In land-based systems, the consistent pattern of increased species richness with increasing number of sites sampled is an ecological norm. In freshwater systems, fish species discharge relationships are analogous to species-area relationships in terrestrial systems, but the relationship between terrestrial species and discharge remains largely unexplored. We tested whether bird species-sampling relationships vary with watershed position, majority land cover class, and distance from rivers. Using data from the Ontario Breeding Bird Atlas (2001-2005), we created bird SSRs to explore how increases in diversity with sites sampled varies with watershed position on the Canadian side of the Great Lakes Basin (GLB). The mosaic landscape of the GLB was further summarized into six majority cover classes at varying spatial scales (i.e., within 15, 70 and 135 m). Using Mixed Models, we tease apart the relationships between variables to explore where we are on the landscape and how this affects our interpretation of species diversity metrics.

**Quantitative modeling to understand how sea turtle populations will respond to climate warming**
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Sea turtles have temperature-dependent sex determination, where hatchling sex is determined by nest temperature during incubation. As global climate change warms beaches, more females and fewer males are
being produced. The extent to which this bias in sex ratio will affect reproduction and population survival is unknown. As part of a collaborative project, we are using population genetics to understand possible plasticity in the breeding sex ratio of green sea turtles at Fernando de Noronha, Brazil, and how the sex ratio will respond to predicted warming. It is only possible to estimate the true breeding sex ratio indirectly, using parentage analysis on hatchlings. Therefore I am using computational simulations to determine how many hatchlings from each nest and how many nests need to be sampled to produce a robust estimate of breeding sex ratio. This will guide field sampling efforts. At the same time, I am developing a size- and sex-structured population model to determine the probability of persistence under different behavioral and genetic adaptation scenarios, which will be informed by field data. Results will inform conservation efforts for green turtle populations globally, including those off the coast of Hawai‘i and the U.S. Virgin Islands.

PHASE ONE OF EELGRASS RESTORATION AND THE ESTIMATED TIME NEEDED FOR SEED COLLECTION
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1- Friday Harbor Labs 2- Friday Harbor Labs, USVI 3- None

Global decline of seagrass species, first reported twenty-five years ago, is a serious problem in the Anthropocene. As these marine angiosperms decline, a trophic cascade of reduced function is followed by dramatic losses in productivity and habitability for organisms that spawn, forage and feed in nearshore waters. Efforts are underway to find economically efficient methods to restore seagrasses in all regions. A technique, pioneered in the Chesapeake Bay in the 1990’s, to restore eelgrass (Zostera marina) using seeds is now widely used throughout the range of this foundational species in the Northern Hemisphere. Recent research for restoration of seagrasses using seeding techniques has shown cost-effective alternatives to traditional transplant methods. Seed collection is a process that takes several weeks and requires many hours in the field, as well as monitoring of the culture system post-collection. Seeds are not directly harvested in the field but require that the flowering head, or inflorescence, of individual reproductive stalks are gathered, before the seeds mature. Flowering heads are located and then removed without damaging the rhizome. After gathering, flowering heads are kept cool and moist and transported to the culture system where seeds ripen, are released and then collected. In this poster, we identify the steps to initiate the first phase of an eelgrass seeding project and quantify the amount of human labor needed to collect ripe seed. This information will be useful to guide efforts to restore eelgrass where seeding programs are being considered.

AQUACULTURE TECHNIQUES ENHANCE THE POTENTIAL FOR PROLONGED SUCCESS IN THE RESTORATION OF BULL KELP, NEREOCYSTIS LUETKEANA
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Bull kelp (Nereocystis luetkeana) is one of the primary canopy forming foundation species along the northeastern Pacific coast, supporting unique and biodiverse communities from central California to Alaska. Its role as a foundation species was recently exemplified when 95% of bull kelp was lost along northern California, with ensuing shifts in ecosystem state. Bull kelp is an annual species and persistence relies heavily on its ability to reach fertility and release spores prior to winter wave disturbance and senescence. Recent coincidence of marine heatwaves, sea-star wasting disease, and expanding sea urchin populations along northern California have resulted in severe interannual bull kelp population declines, posing direct risk to long-term persistence of bull kelp forests and their associated community. Restoration efforts have focused on sea urchin removals and active reseeding of bull kelp at different stages with mixed success. We utilized various aquaculture methods to simplify the cultivation of bull kelp for restoration purposes. Using land-based tanks, we developed low-cost techniques to complete the bull kelp life cycle with flow-through filtered seawater, aeration, and shading. We utilized our methodology to successfully produce gametophytes, free-floating sporophytes, seeded rock substrates, and a perennating soral bank. Incipient in-situ testing of the efficacy of low-cost restoration methods capable of re-establishing bull kelp forests will inform managers for future restoration efforts.

SPATIAL AND DEMOGRAPHIC DIFFERENCES OF THE HAWAIIAN CORAL SPECIES: PORITES LICHEN
Coral reefs are valuable marine ecosystems that are rapidly declining under climate change. Despite years of documented declines in Hawaiian coral cover, we still do not fully understand the demographic processes underlying these patterns, nor the effects of latitude on coral species. Porites lichen is a major reef building species found in the northern section of the Northwestern Hawaiian Island chain, including Kure Atoll (KUR; northernmost), Pearl and Hermes Atoll (PHR; intermediate), and Lisianski (LIS; southernmost). To better understand the drivers of such declines, we measured P. lichen vital rates (i.e. growth rate, recruitment, and mortality) across space and time at KUR, PHR, and LIS. The vital rates for P. lichen were evaluated using Structure-from-Motion photogrammetry to create 3D models of the reefs. We used 2D representations of the 3D models to outline live patches of P. lichen, and calculated the change in area of a minimum of 40 individuals per site in 2016 and 2019. Due to colder waters at higher latitudes, we hypothesize that P. lichen will have more difficulty adapting to climate change conditions and will have less competitive vital rates (decreased growth and recruitment, increased mortality) at KUR compared to PHR and LIS. Preliminary results demonstrate less competitive vital rates at KUR compared to PHR and LIS, suggesting that P. lichen populations may be less tolerant to climate change at higher latitudes. Overall, our data highlights the importance of latitude on coral reefs, and should be taken into consideration during reef management efforts.

COMPETITION OF TURF AND CRUSTOSE CORALLINE ALGAE ON BRANCHING AND MASSIVE CORALcolonies FOLLOWING BLEACHING EVENTS
† Ramsing, K.M.*; Khen, A.; Smith, J.E.
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Turf algae and crustose coralline algae (CCA) represent distinct functional groups on coral reefs. Turf algae are fleshy, fast-growing, opportunistic, and competitive. Since they can overgrow corals and other benthic taxa particularly during disturbances, an abundance of turf can indicate a more degraded reef. CCA are slow-growing, calcifying, and release settlement cues for coral larvae. Their abundance is an indicator of reef health since CCA are active reef-builders. The purpose of this study was to observe growth, competition, and abundance of CCA and turf on branching and massive coral colonies during and following bleaching events on Palmyra Atoll in the central Pacific. We used a yearly photoquadrat time series from 8 sites between 2009-2019. In Photoshop, we extracted planar areas of live coral, CCA, turf algae, or other organisms within borders of bleached or partially-dead coral colonies and tracked them over time. We found that turf and CCA were equally abundant during bleaching events whereas CCA was more prevalent a year later. Also, there was relative stability of calcifiers (i.e., corals and CCA) through time. This shows that CCA have the ability to regrow after disturbances and that pristine reefs can remain generally stable in terms of reef-builder dominance. Understanding these patterns is useful for predicting changes in reef health, especially as oceans warm and conditions become more stressful. Palmyra is a remote, uninhabited reef with no local stressors, so it is also important to consider how reefs with more human impact may respond differently.

SEX AND SIZE DISTRIBUTION OF CALIFORNIA SPINY LOBSTER: SUSTAINABILITY IMPLICATIONS FOR SMALL-SCALE FISHERIES
† Wong, A.1*; Mansfield, E. J. 2; Micheli, F. 3
1- Macalester College 2- Hopkins Marine Station, Stanford University 3- Center for Ocean Solutions, Stanford University

Accelerating impacts of climate change on marine ecosystems and the importance of sustainable fisheries to socio-ecological communities necessitates the use of fishery-specific data to increase sustainable practices. Using 2018-2020 catch and spatial data from a small-scale Baja California fishery, I analyzed sex and size distribution patterns of the California spiny lobster (Panulirus interruptus) population and evaluated fishing intensity across sites. Characterizing the size distribution of lobsters allowed for identification of profitable versus vulnerable fishing sites potentially functioning as nursery habitat. Male:Female sex ratio approached
50:50 with increasing size class, demonstrating a sex-size interactive effect, while a female-dominated catch overall suggests a male-limited population. Large male depletion throughout the season could further impact mating dynamics, reproduction and fishery recruitment. To reduce sublegal-size bycatch, escape gaps should be reassessed and fishing pressure shifted from popular yet vulnerable sites to productive, underutilized sites. This study provides a model for spatial analysis and sustainability management within small-scale fisheries that can eventually facilitate policy development through the designation of limited-take and no-take zones within fisheries corresponding with hotspots of vulnerable individuals. Maps of legal and juvenile lobster hotspots will be shared directly with fishers to enhance community understanding of management practices and encourage informed decision-making for continued sustainability.

**ECOLOGICAL IMPLICATIONS OF THE FOUNDATION SPECIES, FUCUS DISTICHUS AND BALANUS GLANDULA, IN THE FACE OF A HEAT DOME**

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*University of British Columbia*

Habitat-forming foundation species are key in determining community-level responses to environmental stress, especially if they mitigate stress for associated species. However, the degree to which foundation species are functionally redundant or complimentary is poorly known for most systems, and their limits as facilitators are rarely well understood. Here, we explored the relationships between *Fucus distichus*, *Balanus glandula*, and associated species under the severe stress of the record-breaking heat dome event of 2021. We conducted field factorial manipulations of *F. distichus* and *B. glandula* to investigate whether these species provide unique habitat provision services, or if they are functionally redundant. We further investigated the degree to which *F. distichus* and *B. glandula* facilitate one another during periods of environmental stress. Additionally, to explore the effects of temperature and desiccation on the upper limits of *F. distichus* and *B. glandula*, these species were transplanted above their upper vertical position in the field. Our preliminary analyses suggest greater mortality of *B. glandula* when transplanted above its upper vertical position. Furthermore, the preliminary results indicate that barnacles with cover from *F. distichus* were more likely to survive the temperature extremes. This ongoing study provides a more nuanced understanding of the implications of positive species interactions in the rocky intertidal zone and how this ecosystem will continue to change into the future.

**Hungry for Orthologs: Contigs in the pyloric caeca of four prickleback species**

Huang, A. F.*; Kelley, S. S. 1; Herrera, M. 2; German, D. P. 3; Heras, J. 1

1- CSU San Bernardino 2- UC Irvine 3- UC Irvine

Marine intertidal pricklebacks (family Stichaeidae) offer a unique opportunity to understand dietary diversity due to the presence of herbivory, omnivory, and carnivory. There has been an extensive amount of research conducted on relative gut length, enzymatic activity, microbial fermentation in the gut, and other digestive physiological properties of pricklebacks. Here we contribute to our understanding of dietary diversity in pricklebacks by sequencing the transcriptome of the pyloric caeca of four intertidal species of pricklebacks: a carnivore, Anoplarchus purpureascens, an omnivore, Xiphister atropurpureus, and two herbivores, Xiphister musocus, and Cebidichthyss violaceus. Using orthologs we were able to look at unique genes in each genome and compare the presence or absence of these genes across the four species. Looking at the orthologs can help explain their evolution and their lineage. From the pyloric caeca, we detected 3,795 orthologs across the four species, annotated the orthologs, and estimated selection with bioinformatic programs. The goal of our study was to detect orthologous groups among all four species and estimate selection targeted at genes specifically related to digestion. With these results we can analyze these specific orthologs and determine what the digestive evolutionary paths of the four species.

**TEMPERATURE AND FECUNDITY IN RELATION TO COST OF DEVELOPMENT IN THE MARINE AMPHIPOD ANISOGGAMMARUS PUGETTENSIS**

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*University Of British Columbia*
Studies on metabolic life-history theory show that colder temperatures can elicit an adaptive response in ectotherms where mothers offset the increased cost of development by making larger offspring with greater energy. Whether this can have implications on fecundity is unknown. This study’s main objective is to determine if the marine amphipod Anisogammarus pugettensis has an adaptive response to temperature that allows it to change fecundity as the cost of development varies. We hypothesize that fecundity will increase with temperature as the cost of development decreases as long as the temperature is within the species natural range. Outside of this range, we expect to observe that fecundity decreases as the cost of development increases, as suggested in past studies. We tested these hypotheses by experimentally rearing populations of A. pugettensis at different temperatures, and measuring the effect of temperature treatments on fecundity. If our hypotheses are correct, as temperatures increases we can expect that fecundity will initially increase then decrease as temperatures rises above a species’ natural range. Understanding the temperature-dependence of demographic processes such as fecundity and brooding capacity can further our ability to understand population responses to climate warming in natural ecosystems.

A MILESTONE IN THE MAKING: CALIFORNIA’S GLOBALLY RECOGNIZED MARINE PROTECTED AREA NETWORK DECADAL MANAGEMENT REVIEW

Worden, S*; Van Diggelen, A; Wertz, S; Shen, C; Pope, E; Gonzales, K; Slatoff, L; Heitzenrater, T; Prall, M; Salisbury, M

California Department of Fish and Wildlife

In 2012, California finalized implementation of the largest ecologically connected network of marine protected areas (MPAs) in the world. Designed using a scientifically guided, stakeholder-driven approach, the MPA Network consists of 124 individual MPAs and 14 special closures that encompass approximately 16% of California’s jurisdictional waters, with 9% in no-take MPAs. As California approaches the 10-year anniversary of network completion, the California Department of Fish and Wildlife (CDFW) is preparing the first comprehensive review of the MPA Management Program and progress of the MPA Network towards meeting the ecosystem-focused goals of the Marine Life Protection Act (MLPA). The Decadal Management Review will be rooted in the four pillars of the Management Program: Outreach and Education, Research and Monitoring, Enforcement and Compliance, and Policy and Permitting. Several components and data streams will inform the Review and help link Management Program highlights back to the MLPA goals including expert science guidance, Tribal coordination, stakeholder input, gaps in knowledge, and places for improvement. A milestone in California’s history in marine conservation, this first Review will result in broad adaptive management recommendations that will inform future MPA management priorities and network evaluations.

TEMPERATURE AND PREDATOR EFFECTS ON GREEN CRABS (CARCINUS MAE- NAS)

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1- Portland State University 2- South Slough National Estuarine Research Reserve

The invasive green crab (Carcinus maenas) has increased in abundance and distribution among Oregon’s estuaries. Its global success in settling into new environments and tolerance for abiotic stressors raises concern for C. maenas to negatively influence native crab species, especially given global climate change. To improve in predicting invasion impacts, this work analyzed the results from a tank experiment documenting predation pressure on C. maenas across a range of temperatures (9° to 30°C) and predatory crabs Callinectes sapidus, Cancer productus, and, (control) C. maenas. The behavioral responses of prey C. maenas and predators were observed and timed. The C. sapidus preyed heavily on C. maenas, at warmer temperatures; however, C. productus preyed much less on C. maenas and only at the cold temperatures, suggesting different trajectories of biotic resistance across the coasts as waters warm. Additionally, C. productus were most active at 9°C and died at 27°C and higher. In tanks with C. productus, C. maenas were most active and aggressive at warm temperatures. In contrast C. maenas spent more time feeding at 9°C when in warm waters with C. sapidus and, surprisingly, with C. productus. The tolerance demonstrated from C. maenas in warmer temperatures indicates the ability to acclimate and/or adapt. This is of high concern for native species and may pose an increased threat of an invasion by out-competing or maturing sooner to a size that makes C. maenas a successful predator.
INTERACTIVE EFFECTS OF SUBMARINE GROUNDWATER DISCHARGE AND CORAL-CORAL INTERACTIONS ON COMMON CORAL SPECIES, PORITES RUS
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The maintenance of healthy coral reefs is dependent on the growth and physiological responses of corals to abiotic and biotic factors. Submarine groundwater discharge (SGD) is freshwater that flows from land, through the marginal seabed, and onto the reef. SGD can affect corals by altering the biogeochemical properties of the water (e.g., increased nutrients, lower salinity, and temperature). Additionally, biotic interactions affect corals, such as competition with other corals. The ecological effects of SGD are not yet well-studied, and this study tests the combined ecological effects of SGD and competition on coral growth rate and metabolism. Four coral competition treatments (no competition, dead coral, intraspecific and interspecific competition) were deployed at 20 locations along a gradient of SGD for two weeks. To describe the SGD gradient, we measured %N and \(^{15}\)N in Turbinaria ornata at each location. We measured growth, photosynthetic, and respiration rates of Porites rus before and after deployment. Photosynthesis and respiration rates both showed a strongly significant relationship with \(^{15}\)N, while net production had a significant relationship with nutrient loading. Nutrients can be used as a proxy for SGD as SGD increases nutrient input on the reef. These results indicate that along this SGD gradient, there is a higher effect size of nutrient source than nutrient loading on P. rus metabolism. The changes in coral metabolism due to SGD can lead to changes in community composition and other cascading community effects.

MONITORING OCEAN ACIDIFICATION IN CALIFORNIA ROCKY INTERTIDAL HABITATS
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Coastal marine ecosystems are dynamic environments susceptible to the impacts of climate change and ocean acidification (OA). California coastal regions exhibit a spatial mosaic of pH conditions attributed to the presence of two oceanographic regimes, with northern coastal areas exposed to strong, persistent upwelling and southern coastal habitats experiencing weak upwelling activity. This pH mosaic has direct implications for the progression of OA in coastal ecosystems, especially for intertidal communities particularly vulnerable to the effects of OA. The California coastline represents an area of high economic, recreational, and ecological importance; and yet, there is very limited information on the current progression of OA in nearshore habitats. Here, we deployed Durafet-based pH sensors equipped with temperature loggers in rocky intertidal habitats at three strategic locations in California. These sensors measured intertidal pH and temperature at Bodega Marine Reserve (BMR), Lompoc Landing, and Alegria from June until October 2021. Overall, BMR had the greatest pH and thermal variability, the highest frequency of low pH conditions, and the lowest absolute and average temperatures. These results support previous research establishing a latitudinal gradient of thermal stress and a spatial mosaic of pH conditions along the California Current Large Marine Ecosystem. Continued monitoring of the California coastline will be crucial to tracking the progression of OA in intertidal communities and identifying the coastal ecosystems most vulnerable to climate change.

REPORT OF A COPEPOD EGG PREDATOR INFESTING COMMERCIALLY IMPORTANT YELLOW ROCK CRAB IN SANTA BARBARA, CA
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University of California Santa Barbara

Copepods in the family Nicothoidae are highly modified egg predators that mimic the egg shape, color, and size of their hosts. They live within the egg masses of other crustaceans, consuming host eggs and replacing them with their own. While nicothoids have been described from brachyuran hosts in Japan, India, Australia, and the East Coast of North America, to date none have been found in West Coast crabs. At UCSB, ten Metacarcinus anthonyii recently collected from the subtidal zone off of the Santa Barbara coast were found to have been infested with nicothoid copepods, actively consuming the eggs of this commercially important crab. Of the ten M. anthonyii, eight were infested with copepods, and one was so heavily burdened that nearly 100% of its eggs had been replaced with nicothoid eggs. A rapid evaluation of this potential outbreak
will allow for an assessment of whether or not this copepod egg predator represents a threat to the yellow rock crab fishery.

**IMPACTS OF HYPOXIA ON THE PHYSIOLOGY OF JUVENILE ENGLISH SOLE, PAROPHRYS VETULUS**
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1- California State University, Monterey Bay 2- Moss Landing Marine Laboratories

Estuaries, such as Elkhorn Slough on California’s central coast, serve important ecosystem roles, including providing critical nursery habitat for juvenile fish. However, due to eutrophication and climate change, estuaries experience highly variable dissolved oxygen (DO) levels and hypoxia. Though hypoxia negatively impacts juvenile fish, fish may utilize physiological compensatory mechanisms to prevent tissue-level hypoxia. This study seeks to determine how juvenile English sole, Parophrys vetulus, respond physiologically to decreasing DO by measuring metabolic rate and ventilation rate, as well as biochemical indicators of hypoxia (HIF-1 and lactate) and oxidative stress (superoxide dismutase), at six DO levels ranging from ambient to severely hypoxic. While resting metabolic rate did not vary with DO, maximum metabolic rate (MMR) was significantly impacted. We observed a positive correlation between DO and MMR, finding that MMR decreased at lower DO levels. As a result, we also detected a positive correlation between aerobic scope and DO, with aerobic scope decreasing at lower DO levels. A decrease in aerobic scope under hypoxic conditions could severely affect juvenile P. vetulus’ ability to capture prey or escape predation. Future work includes analyzing ventilation rate video, as well as analyzing biochemical indicators of hypoxia and oxidative stress to elucidate tolerance thresholds. Determining how hypoxia in estuarine nursery habitat impacts P. vetulus’ physiology may allow for predictions of future ecosystem dynamics and fishery success.

**THE IMPACT OF HEATWAVES ON GRACEFUL ROCK CRAB GROWTH AND ABILITY TO HUNT AND DEFEND**
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UC Santa Cruz

The Graceful rock crab, *Metacarcinus gracilis*, is vulnerable to the heating effects of climate change. Warmer water temperatures common in the summer months have been enhanced by climate change. To investigate how heat waves affect crab growth and behavior, we subjected 180 Graceful rock crabs to five static temperature treatments, ranging from 16.5°C to 21°C, for one month. After which, we subjected all crabs to a heatwave of 22°C for 3 hours. Following this event, we tested each crab’s defense by timing their ability to turn over after being flipped on their backs. Furthermore, we tested their ability to hunt and eat by giving half of the crabs intact mussels to open and the other half received mussel meat. Crab growth between temperature treatments did not significantly vary. Crabs kept at 16.5°C and 18°C took longer to flip over after the 22°C heatwave than those kept at warmer conditions. There were no significant differences between treatments in their abilities to open mussels or eat mussel meat. Our research concluded that crabs exposed to higher temperatures for the month were less impacted by the short-term heatwave. Large temperature changes likely decrease the crab’s ability to defend itself. In other words, crabs are resilient to higher temperatures when it’s a slower onset.

**EFFECTS OF A NON-INDIGENOUS BRYOZOAN ON THE RECRUITMENT OF THE NATIVE OLYMPIA OYSTER, OSTREA LURIDA**
† Rodriguez, L. *; Valerie Goodwin; Danielle Zacherl

California State University, Fullerton

Non-indigenous fouling organisms settling onto artificial and natural hard substrata in estuaries can negatively impact native species via space competition, predation, or other mechanisms. The effects of Amathia verticillata, and other fouling organisms on the recruitment of Ostrea lurida, were studied to determine whether their biomass and abundance affect oyster recruitment. Terracotta tiles, proxies for available hard substrata, were deployed in Newport Bay, California at tidal elevations between -0.4 and +0.1 feet MLLW, April-October 2020, during the oyster’s spawning and recruitment season. Five treatment groups (n=5 replicates per tile) were established: unmanipulated controls, *A. verticillata* removals, *A. verticillata* plus
other fouler removals, other fouler removals with A. verticillatum additions, and other fouler removals with 2X A. verticillata additions. The treatment groups were maintained by adding or removing A. verticillata foulers as appropriate per treatment; all removals were quantified via volume displacement as a proxy for biomass. During tile retrieval, the volume displacement and wet weight of A. verticillata and other foulers were recorded. Oysters recruiting to the tiles were measured for length and width, identified, and counted. Percent cover of all species recruiting to the tiles using point contact techniques was recorded. Results suggest that A. verticillata is facilitating O. lurida recruitment as A. verticillata removals had lower oyster recruitment.

ASSESSING POPULATION DENSITIES OF SEA URCHINS AND GIANT KELP IN TOPOGRAPHICALLY UNIQUE SITES WITHIN THE MONTEREY PENINSULA
† Denise Drachenberg†; James Lindholm †; Travis Leggett 2
1- CSUMB 2- MLML

Shifts from productive kelp forests to sea urchin barrens have been widely documented. While much is known about species interactions between urchins and giant kelp, there are few field studies relating these phase shifts to topography. Non-contiguous reefs create natural boundaries that inhibit urchin movement and present less area for both urchins and kelp to recruit. Our main focus was to determine if two sites that are geographically close to each other, but topographically unique, would yield different algal and urchin population densities. At each site, we conducted transects, surveys, and photo-quadrats to determine sea urchin densities and kelp counts. Results showed that there was significantly more kelp on the contiguous reef at North Monastery compared to the non-contiguous South site, but no statistical difference between the true mean urchin density of the two sites (W = 2486, p-value = 0.247). However, more analysis needed to solidify these conclusions. This study provides further insight into the effects of topography on local population densities. Additionally, this site comparison will help inform future research regarding kelp forest transitional dynamics.

RIPARIAN WILLOW RESTORATION ON THE MID-KLAMATH RIVER IN THE CONTEXT OF KARUK CULTURAL PRACTICE AND ECO-CULTURAL REVITALIZATION
† Sofi Courtney†; Lisa Morehead-Hillman 2; Cleo Wölfle-Hazard 1
1- University of Washington, Seattle 2- Karuk cultural practitioner

Indigenous eco-cultural revitalization is integral to producing sustainable outcomes in restoration ecology and climate adaptation. However, Indigenous lifeways are rarely incorporated into restoration ecology research. Here, we report on the initial phases of a co-generated field experiment developed by Karuk basket weavers and UW researchers. We aim to investigate how Karuk community stewardship impacts the ecological and basket weaving qualities of riparian Salix species (S. exigua, S. lasiolepis). Karuk basket weavers know that disturbance, such as coppicing, flood scour, and fire, can cause riparian willows to grow long, straight, and supple stems that are excellent material for basket weaving. Following a hundred years of fire suppression, and other settler-colonial land management policies, most basket weavers on the mid-Klamath coppice, rather than burn, willows to produce basketry stems. However, many basket weavers have expressed a desire to use prescribed and cultural burns in order to obtain higher quality basketry stems. Consequently, together we developed a Before-After-Control-Impact experiment, using Karuk science and western science methods, in which we ask: How do coppicing and prescribed fire impact the flexibility and bending strength of willow stems? This works aims to center Indigenous worldviews and environmental justice into restoration ecology research and climate adaptation planning on the mid-Klamath River.

MUSSEL WORKOUT: TEMPERATURE FLUCTUATION’S EFFECTS ON BAY MUSSEL METABOLISM
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Ocean warming poses potentially dramatic ecophysiological challenges to intertidal ectotherms. Experimental approaches exploring the consequences of such thermal stress typically use stable temperatures or simple “block” temperature fluctuations to approximate rapidly changing field temperatures. We used “field” tem-
Temperature data collected from probes deployed in a mussel bed to set rapidly thermal conditions every 5 minutes in a closed flow chamber. Physiological responses (e.g., respiration rates) of mussels (Mytilus trossulus) exposed to field temperature treatments versus stable and “block” treatments were significantly different in warmer treatments, but not in colder treatments. Thus, oversimplified “block” temperature treatments are not acceptable substitutes for actual field data when replicating environments that have drastic daily temperature change, with “block” treatments underestimating field respiration.

Variability in coral recruitment, succession, and net reef accretion on settlement tiles deployed on a remote atoll
Khen, A.1*; Clements, S. 1; Sandin, S.A. 2; Smith, J.E. 3

1- Co-author 2- Principal Investigator and Committee Member 3- Senior Author

Coral reef ecosystems are experiencing disturbance events and thermal bleaching more often than usual due to climate change. The need for new coral recruitment, favorable succession, and increasing net reef accretion is becoming increasingly important. Studying coral recruitment and associated processes will help assess ecosystem health and reveal the system’s capacity for replenishment. While the impacts of climate change have been widely studied in relation to these processes in experimental settings, much less is known about these metrics in situ. Here we assess how recruitment rates, community development (succession), and carbonate accretion on settlement tiles varied across sites/habitats on a remote atoll, Palmyra Atoll. Further, we assessed how these response metrics were related to the benthos. We utilized an existing long-term monitoring dataset (2009-2020) for this study. Preliminary results from 2018 reveal that coral settlement was significantly different across sites and between habitats. Additionally, a positive correlation was found between coral settlement on tiles and the average percent cover of hard corals in the benthos. Calcified algae (mainly CCA) was the dominant early successional species, creating an ideal space for coral settlement. Finally, net reef accretion on Palmyra was higher than other degraded reefs and not significantly different across sites or habitats. These findings will be valuable to compare to other reefs when compiled over time and provide information to coastal communities when inevitably impacted by disturbance events to come.

SIZE DEMOGRAPHICS OF BLACK ABALONE ALONG THE MONTEREY PENINSULA
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1- CSU Monterey Bay 2- Stanford University, Department of Earth and Ocean Science Hopkins Marine Station 3- CSU Monterey Bay, Department of Marine Science

Effective management and recovery of threatened species requires long-term observations of population dynamics. Human and environmental impacts such as predator-prey interactions, overexploitation, and climate change make the recovery of threatened species more difficult. Black abalone (Haliotis cracherodii) are a listed endangered species that have been affected by overexploitation, disease, loss of habitat, and climate change. Abalone are important herbivores within the intertidal and subtidal regions that compete with urchins for habitat and food. As a result of H. cracherodii’s decline, the fishery was closed in the 1990’s and in 2005 CA Fish and Wildlife created the Abalone Recovery and Management Plan (ARMP) that set criteria for the recovery of Black Abalone. A study in 2008 found that abalone size structure and densities were stable and that areas with longer duration of protection saw larger individuals. Fifteen years later we returned to these sites to see if individual species sizes have met any of the criteria set by the ARMP. Our preliminary results are similar to the 2008 study and suggest that population densities remain stable, but still do not meet the ARMP criteria. Observational studies like this one are important in evaluating the effectiveness of management plans for species like the black abalone.

CONTRIBUTION TOWARDS AN ILLUSTRATED IDENTIFICATION GUIDE FOR RIBBON WORMS OF OREGON: CLASS HOPLONEMERTEA, PHYLUM NEMERTEA
Ligorria, J.1*; Orr, R. 2; Ellison, C. 3; Maslakova, S. 3

1- Pomona College 2- Sierra College 3- Oregon Institute of Marine Biology

Ribbon worms include ~1300 described species worldwide, and are important in marine ecosystems as predators. Yet they typically are omitted from biodiversity surveys, or are identified only as “Nemertea” due to
lack of adequate ID guides. A major challenge is the shortage of taxonomic expertise in the face of continuous discovery of many cryptic and undescribed species. This is true even in parts of the world where the fauna is thought to be well studied, such as the West Coast of North America. Furthermore, existing guides typically lack color illustrations, and nemerteans have few characters suitable for morphological identification, aside from the color and shape of body. To alleviate this problem, we collected and photographed nemerteans from nearshore habitats in Charleston, OR during Summer 2021. We confirmed identification of each specimen through DNA-barcoding, and began compiling a photo ID guide, including undescribed species. Here we focus on the class Hoplonemertea (see a companion poster by Orr et al. for the other two classes). Hoplonemerteans possess a calcareous stylet, which they use to envenomate prey; and characters of stylet apparatus help in species identification. Prior work in Oregon by our group revealed 32 hoplonemertean species, 18 of which are undescribed. During this survey we successfully barcoded 22 species. Four of these are new to science, two — new records for Oregon, and one has not been previously seen in its adult form.

INTER TIDAL RELATIONSHIP BETWEEN ALGAL COVER AND PURPLE SEA URCHINS ON THE MONTEREY PENINSULA
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Herbivores can drastically shift their environments by consuming foundational species. The purple sea urchin, a common marine herbivore, plays a key role in kelp forest communities by controlling the abundance of kelp via grazing. Sea urchins are a source of prey for many marine species and also contribute to commercial fishing industries. Recently, marine heatwaves and overgrazing have drastically decreased the amount of kelp in subtidal zones, leading to a shift towards urchin barrens. While much is known about the dynamic between large kelp and subtidal sea urchins, there have been few studies that focus on the relationship between sea urchins and algal species in the intertidal. We used quadrats to collect density and size structure data on purple sea urchins at six sites along the Monterey Peninsula. We measured the percent cover of algae using quadrats spaced every three meters along the transect and recorded habitat type every half meter. Our results showed that areas with higher urchin density were linked to greater amounts of encrusting algae. We also found more urchins located on boulders than any other habitat type. Further studies are needed to better understand the drivers of the urchin population expansion. This study will provide important information on the status of local species and can be used to inform ongoing conservation efforts.

ASSESSING POPULATION DENSITIES OF BLACK ABALONE (HALIOTIS CRACHERODII) ALONG THE MONTEREY PENINSULA
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Abalone are gastropod molluscs that live in subtidal and intertidal environments and are a popular food source for many coastal communities. Decline in the black abalone (Haliotis cracherodii) species has made it a priority for management and conservation efforts. Since the 1960s, drastic decreases in abalone populations caused abalone fisheries south of San Francisco to close in 1997. In 2003, the Department of Fish and Wildlife established the Abalone Recovery and Management Program (ARMP). Despite these conservation efforts, a study on black abalone published in 2008 found that most areas did not meet the required densities for population or fisheries sustainability along the Monterey Peninsula and in 2009, black abalone were listed as an endangered species under the US Endangered Species Act (ESA). In the summer of 2021, we revisited five of the eight sites from the 2008 study and two new sites to assess intertidal abalone densities. We conducted six, 20mx2m transects at each site. Our main focus is to determine if black abalone populations now meet the recovery criteria outlined in the ARMP. Preliminary findings suggest that though black abalone populations have remained stable since 2008, recently there have been marked declines. With our findings, we will gain a better understanding of the local black abalone communities and how to better protect this endangered species.

HIGH HEAVY METAL CONCENTRATION IN SEAFOOD FROM CHINESE MAJOR INDUSTRIAL CENTERS
China is the world’s largest seafood-consuming country and consumes about 65,000,000 tons of seafood annually. However, as the development of industrial factories progresses, pollution discharge in water has increased in the past two decades. Here I investigate heavy metal concentrations in several marine invertebrates from three different Chinese industrial centers: Bohai Rim, Yangtze River Delta, and Pearl River Delta. Samples were collected from local seafood markets and China’s largest online-shopping platform, Taobao (https://world.taobao.com/). Samples are three species of bivalves, and one crab species (as an example of a higher trophic level predator). Samples were tested for Cadmium and Arsenic concentrations using ICP-MS analysis by an external testing facility. Results show that 6 out of 14 samples have cadmium concentration over the Chinese National food safety level (0.5 mg/kg). 14 out of 14 samples had arsenic concentration over food safety level. Follow-up sampling after the rainy season showed a significant decrease in the heavy metal concentration. These data indicate the growing conflict between reliance on seafood resources and increasing industrialization.

**The Hidden Majority: Biodiversity and Ecological Functions of Species Residing in Cryptic Coral Habitats**


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Coral reefs are home to over 93,000 described species that comprise a complex web of ecological interactions. However, previous survey data of reefs has largely excluded the biodiversity and ecological function of coral crevices due to their cryptic nature and lack of accessibility. When these habitats are included, reef biodiversity estimates are closer to one million species. Here, we review the current state of cryptic habitat exploration on coral reefs, present new data on the biodiversity of cryptic crevices, and suggest next steps for understanding these underexplored environments. In reviewing relevant literature, we found that most studies focused on describing species diversity rather than the ecological function of these communities. Articles that discussed ecological function, emphasized the importance of cryptic sponges in facilitating nutrient flow throughout the reef. Many studies focused on the role cryptobenthic fishes play in marine food webs but did not consider the contributions of cryptobenthic invertebrates. To further investigate species assemblages *in situ*, we collected video data of reef crevices in West Maui, which showed relatively high abundances of crustose coralline algae (CCA). CCA was noted in previous crevice studies but never examined in-depth, yet its presence signals calcium carbonate accretion that ultimately builds reefs. We suggest that future research should explore how CCA and other calcifiers that are known to be critical in reef construction, contribute to reef stabilization, ecosystem function, and resilience of coral reefs.

**REDUCE, REUSE, RESPIRE: TWO ENVIRONMENTAL FACTORS’ EFFECTS ON MUSSEL RESPIRATION**

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Mussels are important due to their role as ecosystem engineers within the intertidal as well as a valuable fishery. However, these organisms are under threat of not only increasing ocean temperatures, but could be made more vulnerable as a result of low wave action at their respective sites. The physiological performance of *Mytilus trossulus* was quantified by measuring respiration rates under five different water temperatures (e.g., 5, 11, 17, 23, and 29 °C) and five different flow velocities (e.g., 2, 4, 6, 10, and 20 cm s$^{-1}$) in a fully crossed design. Results suggest an important interaction between temperature and flow impacting respiration rates. At the highest flow of 20 cm s$^{-1}$, mussels had higher respiration rates and were generally consistent at the flows of 4, 6, and 10 cm s$^{-1}$. However, at the lowest flow of 2 cm s$^{-1}$, respiration rates were higher than the intermediate flows. This can be applied to future research into performance in mussel beds under future climate conditions, with mussels deeper within the bed being able to respire at lower flows contrary to prior thought.
SKELETAL PROPERTIES IN THE DEEP SEA CORAL LOPHELIA PERTUSA ARE SENSITIVE TO ENVIRONMENTAL CONDITIONS
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Lophelia pertusa is a cold-water, deep sea scleractinian coral that resides in the Gulf of Mexico and the North Atlantic. Prior surveys have shown differences in seawater chemistry among locations where L. pertusa is found. Here, we asked if such differences in seawater chemistry, or other collection site specific parameters, impact the biomechanical and elemental properties of the coral skeleton. Live L. pertusa were collected from six sites in the Gulf of Mexico. We tested micromechanical properties and elemental content of the coral skeleton in two body regions, the calyx and septa. Microhardness, a measure of a material’s resistance to deformation, was affected by both collection site and skeleton region. Microhardness tended to be highest for corals collected in the Viosca Knoll region of the Gulf of Mexico, and for all collection sites, microhardness was higher in the calyx than the septa. Similar patterns were observed for skeletal calcium content, with variation among collection sites and substantially higher calcium content in the calyx as compared to the septa. dbRDA (distance-based redundancy analysis) revealed a significant effect of collection site depth, temperature, and pH (but not aragonite saturation site) on measured mechanical and elemental variables. These results suggest that the L. pertusa skeleton is sensitive to environmental conditions. Further changes in seawater chemistry associated with acidification may alter skeletal properties of L. pertusa, potentially making them more susceptible to mechanical damage.

USE OF REMOTE SENSING IMAGERY TO DETECT AND ANALYSE A COASTAL LANDSLIDE AND CHANGES IN KELP FOREST CANOPY COVER
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One challenge with scientific projects involving field work is that we are rarely able to observe our field sites constantly. For example, when a disturbance to a foundation species occurs in between sampling dates. While conducting a monitoring study of a restored kelp forest on the coast of Palos Verdes, California, a coastal landslide occurred near the study sites in early January of 2019. At the time of the landslide, no instruments were deployed to collect monitoring data. This study demonstrates how remote sensing imagery can be used to analyze coastal turbidity due to a landslide in lieu of in-situ data. Remote sensing imagery from PlanetScope 4-band satellites was used to detect when the landslide occurred and determine for how long high turbidity persisted in the area after the event. Satellite images of the study sites were atmospherically corrected and turbidity values were calculated using the program ACOLITE. Turbidity values from the study sites were compared with monthly kelp canopy cover from July 2016 through November 2019 to quantify changes to kelp canopy cover before, during, and after the landslide. The landslide was first detected on January 6, 2019, and low kelp canopy coverage extended throughout 2019. The ability to detect events such as landslides is important because suspended sediment can impact the availability of light and food and cause reef burial which may have significant consequences for nearshore communities.

VEGETATION RECOVERY IN A SALT MARSH AFTER SEDIMENT AUGMENTATION
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Wetlands are an integral part of coastal ecosystems in Southern California, having both intrinsic and economic value. Wetland ecosystems filter water, prevent erosion, and provide habitat to a diverse group of organisms that have adapted to live in this fluctuating environment. However, there has been a decline in wetland area and quality, due to anthropogenic influences. Sea level rise (SLR) is of particular concern to wetlands as this will increase their loss. One possible solution to this predicted loss is sediment augmentation, the addition of sediment to a marsh plain to raise its elevation. At Seal Beach National Wildlife Refuge (SBNWR), sediment augmentation was conducted to combat high relative rates of SLR. Recovery of the marsh plain in terms of vegetation cover and bird use was documented over several years at SBNWR using camera time lapses. Examination of photographs taken from theses cameras during a two-year period showed slow regrowth of
wetland plants and variable but increasing use of the marsh plain by birds. This method has proven to be effective at looking at larger organisms interacting with the wetland such as birds. Time lapse cameras can be a great tool for looking at larger organisms using wetlands during recovery periods.

EARLY INSIGHT ON INFAUNAL COMPOSITION PRIOR TO DISTURBANCE BY THE EUROPEAN GREEN CRAB CARCINUS MAENAS
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Benthic infauna are aquatic macroinvertebrates (e.g., polychaetes, crustaceans, and molluscs) living within sediments worldwide. A key characteristic of infauna in marine ecosystems includes bioindication of habitat condition and disturbance. However, opportunities to study communities prior to a significant disturbance are often rare, especially in wild populations. The Padilla Bay National Estuarine Research Reserve in Washington, USA is a critical eelgrass estuary currently threatened by an early stage C. maenas invasion. We used this opportunity to establish baseline data on the infaunal community assemblages present within Padilla Bay prior to the disturbance. Benthic sediment cores were collected from 5 sites (n = 6 samples site−1) across distinct habitat types, with macroinvertebrates in the cores counted and identified. Findings indicate a rich infaunal community with distinct invertebrate assemblages in different areas of the bay. A combination of elevation, sediment composition, and density of the eelgrass Zostera marina best correlated with the observed infaunal community patterns. While our sampling has been limited to a few sites within a year, preliminary data show a patchwork of species likely to be impacted by the arrival of C. maenas, an extreme modifier of invaded habitats. We anticipate continued sampling over time and in a wider range of habitats to establish a clear background against which to measure post-invasion effects of C. maenas in the bay.

FISHERIES MANAGEMENT IN ACTION: RECREATIONAL CATCH OF KELP BASS FOLLOWING A REGULATION CHANGE
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Kelp bass (Paralabrax clathratus) is one of the most commonly caught species in the southern California recreational ocean fishery. In 2013, California imposed more restrictive fishing regulations on kelp bass, which is managed together with barred sand bass (Paralabrax nebulifer) and spotted sand bass (Paralabrax maculatofuscatus). The bag limit decreased from ten fish to five fish in aggregate for the three saltwater bass species, and the minimum size limit increased from 12 to 14 inches total length. Using fishery-dependent data from the California Recreational Fisheries Survey (CRFS) collected by the California Department of Fish and Wildlife (CDFW) from 2012-2019, we examined patterns of kelp bass catch from both the private fleet and commercial passenger fishing vessels. After the regulation change, catch per unit effort of retained kelp bass initially declined but later generally recovered in both segments of the recreational fishery. Notably, the reported number of released fish approximately tripled over the study period. Kelp bass is a relatively slow-growing species, taking eight years to reach legal harvest size. With a high proportion of total catch reported as released, it may only be a matter of time before undersized individuals recruit into the fishery. Additionally, kelp bass is a species likely to benefit from California’s network of marine protected areas (MPAs), completed in 2012. CDFW is currently processing high-resolution (1 nm x 1 nm) CRFS spatial data, which will allow future analysis of recreational catch in relation to MPAs.

WHOLE-GENOME RESEQUENCING OF THE KEYSTONE PREDATOR PISASTER OCHRACEUS ACROSS AN EXPANSIVE ECOLOGICAL CLINE
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Contemporary studies using whole-genome sequence data have challenged the long-held assumption that ma-
rine species often exhibit long-range panmixia, finding instead that structural connectivity varies, sometimes drastically, from functional connectivity. This implies that subtler local adaptation may well be present and relevant to the persistence of aquatic organisms across time and space. Such discoveries highlight the need for advancements in our understanding of environmental factors which drive genomic architecture in ecologically valuable marine species whose populations are identified as at-risk. The keystone predator *Pisaster ochraceus* (ochre sea star) once dominated rocky intertidal ecosystems, but populations throughout its broad range (Alaska to Baja California) have recently suffered mass mortality due to an elusive wasting disease. Early work using mtDNA markers alone generated evidence for intraspecific adaptive differentiation in *P. ochraceus*, so we used whole-genome resequencing to rigorously investigate the underlying structure of populations across an expansive ecological cline. Here, we present preliminary data for 95 resequenced ochre star genomes from five distinct regions spread throughout their native range. Our future efforts will be concentrated on SNP discovery and identification of populations with higher adaptive capacity under projected conditions. By exploring the genetic architecture of a threatened marine organism, we gain insights into how we should protect and manage their populations in a changing world.

**EFFECTS OF TILE ORIENTATION AND COMPOSITION ON OYSTER RECRUITMENT IN SAN DIEGO BAY**

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Hardened shorelines dominate Southern California bays. Much of this habitat is human-introduced, which may favor non-native species recruitment. In San Diego Bay, two oyster species are common on hardened substrata, the native Olympia oyster, *Ostrea lurida*, and the non-native global invader, *Magallana gigas*. These substrata vary in orientation and surface complexity from shell/cobble with high rugosity and varied orientations to vertical seawalls lacking rugosity. To examine whether substrate characteristics favor native versus non-native oysters, we studied the effects of orientation and surface complexity on oyster density and cover. We deployed concrete tiles at different orientations (down-facing, up-facing, vertical) and rugosities (5 treatments, n=3 per treatment) in San Diego Bay from June 2019 to June 2020. We measured rugosity and identified and counted oysters and oyster percent cover. Three-way ANOVAs tested whether orientation, rugosity and species affected density and percent cover. Both species achieved highest densities on down-facing tiles but *O. lurida* density was more reduced than *M. gigas* by other orientations. *O. lurida* density was 3-3.7 x higher than *M. gigas* on vertical and down-facing tiles. *M. gigas* cover was 5 x higher than *O. lurida* on up-facing tiles; orientation did not affect *M. gigas* cover but *O. lurida* was greatly reduced on up-facing tiles. *O. lurida* outnumber *M. gigas* but *M. gigas* occupies more space. To favor native *O. lurida*, resource managers could introduce more down-facing orientations to substrata on armored shorelines.

**UNDERSTANDING THE EFFECTS OF OCEAN ACIDIFICATION ON GASTROPODS UTILIZING THE COSMAN SHELL COLLECTION**

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As carbon dioxide from human emissions continues to be absorbed into the oceanic carbon sink at high levels, the pH of the ocean will continue to decrease and acidified conditions will worsen. One consequence of this is faced primarily by calcifying organisms, like animals that build shells or hard corals; the carbonate necessary to create their calcium carbonate structures becomes limited, and existing shells may dissolve as well. This can have further ecological consequences such as loss of species diversity and narrowing of suitable species range. Utilizing the Cosman Shell Collection as a long-term change over time data source, this research seeks to further understanding of how ocean acidification affects gastropod shells across a range of taxonomic families. Additionally, because of the novel nature of research that uses natural history collections to study ocean acidification, this work will aid in the development of best practices and methodologies for future studies. This is a single-site study of specimens collected at Waianae, Oahu, Hawaii and will cover multiple gastropod families for adequate sample size and wider species representation. Physical parameters to be measured include basic traits such as shell length, width, thickness, and dry weight; in addition to this, shell density and calcification will be calculated, along with limited scanning electron microscopy to observe shell integrity at the microscopic level. Change over time analysis will be conducted in order to determine
how ocean acidification has affected gastropods in the marine environment.