Western Society of Naturalists

101st Meeting Program
~ 2020 ~

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101st Annual Meeting

November 5 - November 8 2020
Virtual Meeting
Welcome to the 101st 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 101st 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 nearly 900 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/web/wsonc_202007/

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/wsonc_202007/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 website 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. This interface is new for most of us. 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 2020 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 Student and Presidential Symposia, the DEI Plenary, the Presidential Address, and the Closing plenary - 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 by adding comments and questions in the Whova chat boxes, however.

The contributed talks will be held in concurrent sessions and hosted as Zoom meetings. You can have your camera on and unmute your microphone to ask questions in the concurrent sessions. We remind everyone that the WSN 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 75% 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

You can either join a talk by joining a session (labelled as the session name) or a subsession (labelled as an individual talk) in Whova. Either way, you will be able to continue watching the entire session through these links. *Please note that session and subsession links have separate Q&A boxes, which can lead to confusion. 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 link to leave questions for speakers to answer later. Thus, if possible, we recommend that you join each session through the session link itself. If you join a session through a subsession link, we suggest opening the session link separately in a second tab or browser window (to avoid interrupting video playback) and allow you to access the correct Session Q&A box.

Joining a presentation session will open a Zoom window inside Whova. This embedded Zoom window acts a bit differently, so please note the following:

- 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.
- Do not use the chat box within the Zoom window, except during very large plenary or symposia. For concurrent sessions, use the Whova chat and Q&A boxes positioned to the right of the Zoom window. (see section below on asking questions)
- Click the “participant” button within Zoom to access the “raise hand” control. This will allow you to alert the moderator that you have a question to ask live.
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.
Each set of 5 minute talks has a 20 minute Q&A session at the end. 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. 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, you will be asked to type your questions directly into the Zoom Q&A (note this is different!), and questions can be upvoted during the webinar by other participants. After the session, you can also post questions for a specific panelist/speaker in the Whova Q&A box found within the specific subsession link. Note there is no guarantee that these questions will be answered.

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 “Exhibitors” 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 Sunday morning with live Q&A over Zoom.
Poster session live Q&A
On Sunday November 8th from 9:00 - 12:00 there will be a live Q&A for poster presenters that will take place in 3 concurrent Zoom rooms labelled Poster Session 1-3. 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.

Posting announcements and coordinating meet-ups using Slack
- Announcements will be posted daily
- We will send important announcements through the Community > “Organizer Announcements” in Whova and in the WSN 2020 Slack channel
- Join our WSN2020 Slack channel here. We will also send this invite through the Announcements in Whova.

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!). Two Wonder rooms will be open for the duration of the meeting: the Topical Cafe for session-specific conversations and the Off-Topical Cafe for casual meetups and chit-chat. Links to these rooms can be found at most of the coffee breaks, but feel free to join these rooms at any time and meet-up with fellow attendees!
- The Off-Topical Cafe is open and available now! Give it a try and see what other WSNers are around! Click here.
- 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.

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. To see what others in the WSN community are up to, be sure to follow us!

2020 Student Committee
Yaamini Venkataraman (Co-Chair; University of Washington)
Jason Toy (Co-Chair; University of California, Santa Cruz)
Theresa Burnham (San Diego State University/UC Davis)
Ric de Santiago (San Diego State University/UC Davis)
Montana McLeod (Oregon State University)
Bryce Perog (California State University, Fullerton)

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. Thank you!

Merchandise
Order online this year! https://www.wsn-online.org/wsn-2020-merchandise/
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/WSNSilentAuction2020
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 Montana McLeod at montana.mcleod@oregonstate.edu.

**Special Auction - In Honor of John Pearse**

To honor John Pearse, we would like to take this time to commemorate his contributions to WSN and his incredible work in ecology. John and his family have donated 100 books to WSN to support the Student Travel Fund. Mark Carr will take this time to honor John and promote members to bid on John Pearce’s donated book collection. To bid on this collection, please see the following link.

https://tinyurl.com/y27z6ugp

**Trivia Night!**

Join us Friday November 6th from 6-8pm 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: crowd.live/WSN2020 (No App required)

Sign-up your team name: https://tinyurl.com/y33jb5al  Sign up to secure a team name for trivia night! Team names must be created before 5pm on Friday 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

THURSDAY, NOVEMBER 5, 2020

1600-1900 THURSDAY WORKSHOP (capped at 50 participants)

“Who Tells Your Story: Designing an Effective Science Website”

FRIDAY, NOVEMBER 6, 2020

0800-0820 Pre-meeting tips and tricks, rolling slides with info

0820-0830 Meeting welcome and general announcements

0830-1000 STUDENT SYMPOSIUM

“Collaborative Science: How Collaborations Have Made Waves”

1000-1030 AWARDS: LIFETIME ACHIEVEMENT AWARD, presented by WSN President Danielle Zacherl

NATURALIST OF THE YEAR AWARD, presented by Arley Muth Rosemary Romero: Connecting people to science through natural history

1030-1100 Coffee Social in Wonder (informal and optional) or break

1100-1230 DIVERSITY, EQUITY AND INCLUSION SYMPOSIUM (Beyond Broader Impacts: The Role of Diversity in Advancing Discovery and Innovation in Ocean Science)

1230-1330 Lunch break - [rolling announcements / coffee break rooms - find them on Whova]

1330-1430 CONTRIBUTED PAPERS (5 concurrent sessions)

1430-1530 CONTRIBUTED PAPERS (5 concurrent sessions)

1530-1545 Break

1545-1745 CONTRIBUTED PAPERS (7 concurrent sessions)

1800-2030 ATTITUDE ADJUSTMENT AND TRIVIA NIGHT (using Wonder and YouTube live stream)
SATURDAY, NOVEMBER 7, 2020

0900-1145  PRESIDENTIAL SYMPOSIUM (*Blue is the New Green: A Key Role for Oceans in Solutions to Climate Change*)

1145-1300  Lunch break [rolling announcements / coffee break rooms - find them on Whova]

1300-1400  CONTRIBUTED PAPERS (5 concurrent sessions)

1400-1500  CONTRIBUTED PAPERS (5 concurrent sessions)

1500-1530  Break [NOTE: *John Pearse special session begins at 1500*]

1530-1730  CONTRIBUTED PAPERS (8 concurrent sessions)

1745-1900  ANNUAL BUSINESS MEETING. All members are welcome - come help shape the future of our society!

1930-2000  WSN Auction - find links on Whova for auction event and bidding

2000-2100  Presidential Address by Danielle Zacherl

SUNDAY, NOVEMBER 8, 2020

0900-1200  WSN POSTER SESSION [three concurrent zoom rooms in 6 30-min blocks]

1200-1300  Lunch break [rolling announcements / coffee break rooms - find them on Whova]

1300-1400  CONTRIBUTED PAPERS (5 concurrent sessions)

1400-1500  CONTRIBUTED PAPERS (5 concurrent sessions)

1500-1515  Break

1515-1615  SPECIAL PLENARY SPEAKER
*Dr. Jane Lubchenco: The Intersecting Worlds of Personal, Public, and Planetary Health*

1615-1630  FINAL ANNOUNCEMENTS and MEETING CLOSE
Contributed Talks
Session 1: Applied Ecology 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

ABIOTIC AND BIOTIC CONTROLS ON THE BIOMASS OF A BROWN MACROALGA ON CORAL REEFS IN FRENCH POLYNESIA (YOUTUBE)
Bittick, S.J. †; Fong, C.R. †; Degregori, S. †; Leber, C.A. †; Duffy, E. †; Williams, C. †; Sura, S.A. †; Barber, P.H. †; Fong, P. †

1- Loyola Marymount University 2- CSU Northridge 3- UCLA 4- UCSD 5- CSU Monterey Bay

As is the case on coral reefs worldwide, reefs in French Polynesia are experiencing increased presence of macroalgae. In particular a brown macroalga, Turbinaria ornata, has increased in abundance and range since the 1980s. This macroalga forms dense aggregations on hard substrate and there is recent evidence that it may exist as an alternative stable state with coral. On the fringing reefs, there are distinct reef zones in which T. ornata dominates but the main distribution controlling factors are unclear. Mature T. ornata is slow growing in response to nutrients and not readily consumed by herbivores. However, we investigated whether herbivory, nutrient availability, and depth can control the establishment of the alga at small size classes (<5cm). We conducted a transplant experiment in both the shallow Turbinaria dominated zone (TZ) and at the crest of the fringing reef below the zone where Turbinaria dominates (BTZ). The experiment utilized nutrient enrichment (+/- Nutrients) and caging (+/- Cage) assays to determine whether nutrient availability, herbivory pressure, or the interaction of these two factors is most important in controlling the establishment of small T. ornata individuals. In all treatments, growth of T. ornata was highest in the TZ, herbivory was increased in the BTZ, and nutrients always caused an increased in the physical anti-herbivory defenses of the alga. This suggests that the ability of T. ornata to establish in a new habitat is controlled by a complex interaction between nutrient availability and herbivory.

CORAL REEF MONITORING USING UNDERWATER PHOTOGRAMMETRY AND GEODETIC SURVEYING

1- UC Santa Barbara, USA 2- ETH Zurich, Switzerland and Aix-Marseille Université, France 3- University of Modena and Reggio Emilia, Italy 4- FBK—Bruno Kessler Foundation, Italy 5- ETH Zurich, Switzerland 6- Microsoft Corporation, USA

Underwater photogrammetry is increasingly being used by marine ecologists because of its ability to produce accurate, spatially detailed, non-destructive measurements of benthic communities, coupled with affordability and ease of use. However, independent quality control, rigorous imaging system set-up, optimal geometry design and a strict modeling of the imaging process are essential to achieving a high degree of measurable accuracy and resolution. If a proper photogrammetric approach that enables the formal description of the propagation of measurement error and modeling uncertainties is not undertaken, statements regarding the statistical significance of the results are limited. In this paper, we tackle these critical topics, based on the experience gained in the Moorea Island Digital Ecosystem Avatar (IDEA) project, where we have developed a rigorous underwater photogrammetric pipeline for coral reef monitoring and change detection. Here, we discuss the need for a permanent, underwater geodetic network, which serves to define a temporally stable reference datum and as a check for the time series of photogrammetrically derived three-dimensional (3D) models of the reef structure. Most importantly, we incorporate the measurement and modeling uncertainties of the full photogrammetric process into a simple and
flexible framework for detecting statistically significant changes among a set of models collected as part of a long-term series investigating changes in the benthic community on the fore reef of Moorea at spatial scales of up to 250m².

**USING A NOVEL LITERATURE REVIEW AND SYNTHESIS OF EXPERIMENTAL DATA TO BUILD RANGE-WIDE SUITABILITY METRICS FOR DREISSENID MUSSELS**

† Brownlee, S.*

*Simon Fraser University*

Zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugensis*) are major invaders of freshwater ecosystems across North America and Europe. In North America, their advance westward across the continent from their point of origin in the Great Lakes has driven many native freshwater mussel species to extinction and disrupted ecosystems across their invaded range. These mussels are spread through the movement of personal watercraft over land between water bodies, commonly via larvae contained in bilgewater or adults encrusting the exterior hull. Predicting the spread of these mussels is therefore an ongoing challenge for managers, due to the inherent unpredictability of human operators and the difficulty of tracking introduction events. A proactive approach is therefore required, where water bodies can be evaluated for suitability before a potential introduction and resources can be targeted towards those water bodies that are suitable for the mussels to become established in. Here we present a novel, rigorous methodology for evaluating the drivers of zebra and quagga mussel distribution on the landscape via a systematic literature review and synthesis of experimentally-derived performance curve data from across the mussels’ invaded range. This methodology will provide useful information to managers on which water bodies are suitable across time and space, as well as identify important knowledge gaps for future research on the forces driving the expansion of this invasive species.

**Species Inventory of the Channel Islands National Marine Sanctuary**

Buhl, J. S.†; Zelinski, V. L. ‡; Yarbrough, B. ‡; Lonhart, S. I. ‡; Caldow, C. †

1- NOAA Channel Islands National Marine Sanctuary 2- University of Miami RSMAS 3- University of Maine 4- NOAA Monterey Bay National Marine Sanctuary

The Channel Islands National Marine Sanctuary (CINMS) is a region of incredible biodiversity off the coast of Southern California. Designated as a sanctuary in 1980, these islands lie at the confluence of the California Current coming from the north and the Southern California Counter Current from the south. It is both the southernmost range endpoint for some species and the northernmost for others. Despite being a heavily studied region, the sanctuary lacks a comprehensive inventory of all the species inhabiting the waters. This year, CINMS joined the west coast wide multi-year effort to inventory all of the species in the sanctuaries. Being aware of the species residing in the sanctuary will provide critical information to support a variety of sanctuary resource assessment needs: protecting sensitive habitats home to rare species, separating native and non-native species, quantifying climate change impacts, as well as identifying data gaps in our knowledge for future research. The use of a standardized methodology involving literature reviews, working with local natural history museum collections, and discussions with taxonomic experts allows this effort to be exportable to other sites throughout both the sanctuary system and other regions of biological significance. The CINMS inventory is currently a work in progress with already 3612 species documented from 24 different phyla.
**A NOVEL FIELD-BASED METHOD OF VECTORING THERMOTOLERANT ALGAL SYMBIONTS (FAMILY SYMBIODINIACEAE) INTO CORAL COLONIES** (YOUTUBE)

† Buzzoni, D.¹; Allen, C. ²; Cunning, R. ³; Baker, A.C. ²

1- Rosensteil School of Marine and Atmospheric Science (University of Miami), Department of Biology (University of Victoria) 2- Rosensteil School of Marine and Atmospheric Science (University of Miami) 3- Rosensteil School of Marine and Atmospheric Science (University of Miami), John G. Shedd Aquarium (Chicago)

*Durusdinium trenchii* is known to confer greater thermal tolerance to its coral hosts than other Caribbean algal symbionts and shows transient abundance increases on reefs after bleaching events. In the lab, some corals can be induced to host >99% *D. trenchii* through controlled bleaching and recovery, but the stability of these communities is not well understood. Building on previous lab experiments, we aimed to test the ability of *D. trenchii* to infiltrate field colonies through its introduction in tissue implants. We collected replicate 2.5cm-diameter cores of three common mounding corals from reefs off Miami and manipulated these cores in favor of *D. trenchii*. We implanted cores back into their parent colonies, and symbiont communities within cores and in the surrounding tissue were monitored. This experiment was repeated twice, with implants introduced near seasonal temperature maxima and minima. Background levels of *D. trenchii* have spread from implants in *Montastraea cavernosa*, and *D. trenchii* has remained dominant in implants for at least 7 months, even throughout the winter. We expect the spread of *D. trenchii* during the summer to have been even more pronounced. These results provide a proof-of-concept for the vectoring of symbionts into field colonies using tissue implants. This has ramifications not only for the competition dynamics that shape *D. trenchii*’s abundance on Caribbean reefs but may also provide a mechanism to alter colonies’ symbiont communities in situ to increase their resistance or resilience to the stressors of a changing ocean.

**CHARACTERIZING THE HUMAN COMPONENT: IMPLEMENTING ECOSYSTEM BASED MANAGEMENT IN THE CHANNEL ISLANDS SANCTUARY**

Duncan, E.A.¹; Selgrath, J. ²

1- Channel Islands National Marine Sanctuary 2- Cardinal Point Captains, Inc.

The National Marine Sanctuary System is mandated by Congress to manage protected places of special significance that provide ecological and economic benefits to the nation. The Channel Islands National Marine Sanctuary (CINMS) provides a number of these benefits to stakeholders, including commercial and recreational fishing opportunities, kayaking, diving, sailing, wildlife viewing, and more. Given the broad array of visitors, effectively managing resources within the sanctuary requires an integrated approach that explicitly acknowledges the linkages and feedbacks between humans and the health and status of the ecosystems in the sanctuary. In many cases, though, actively monitoring the human components of an offshore marine ecosystem is not feasible due to a number of constraints. This project explores a number of existing data sets, primarily collected for other purposes, to evaluate and synthesize information on visitor use to inform sanctuary research, education, and management strategies.

**SHIFTING PHENOLOGY OF SOUTHERN RESIDENT KILLER WHALES IN THE CENTRAL SALISH SEA** (YOUTUBE)

Ettinger, A.E.¹; Harvey, C.J. ²; Samhouri, J.F. ²; Emmons, C. ²; Hanson, M.B. ²; Ward, E.J. ²; Olson, J.K. ³
The timing, or phenology, of predator activity in relation to their prey is critical for survival and fitness, yet is rarely quantified for marine species, even those of conservation concern. Management of threatened migratory marine mammals may be improved by incorporating a rigorous understanding of their phenology and phenology of critical interacting species. We use a large database of professional and citizen science observations analyzed with hierarchical spline occupancy models to quantify seasonal variation in activity of an endangered apex predator, the southern resident killer whale in the Central Salish Sea. We find that the timing of SRKW activity shifted later in summer core habitat in the Salish Sea: the day of year of peak occurrence probability shifted later at rates of 1-5 days per year from 2001-2017. These shifts are consistent with shifts in their preferred prey, Chinook salmon, as the relative number of fish returning to the Fraser River in the spring has declined compared to numbers returning in later summer and fall. The shift in timing of fall/winter SRKW activity in Puget Sound proper, however, is not consistent with shifts in other prey populations (Chinook, coho, chum salmon) returning to rivers in Puget Sound. Our findings demonstrate the complexity of consumer phenological responses, underscore the importance of considering phenology explicitly in management strategies to benefit SRKWs, and highlight gaps in our understanding of links between management actions that affect phenology and consequences for organisms relying on those resources.

THE ROLE OF DRIVERS, DISTURBANCE, AND ECOSYSTEM CONNECTIVITY IN COASTAL BLUE CARBON STORAGE (YOUTUBE)

Ewers Lewis, C.J.1; Carnell, P.E. 2; Sanderman, J. 3; Baldock, J.A. 4; Ierodiaconou, D. 2; Young, M. 2; Rogers, K. 5; McGlathery, K. 1; Berg, P. 1; Macreadie, P.I. 2

Salt marshes, mangroves, and seagrasses are dense ‘blue carbon’ (C) sinks, but limited scientific understanding has slowed the adoption of blue C projects for climate restoration on broad scales. Our research aims were three-fold: (1) quantify sediment C stocks and elucidate drivers of variability, (2) quantify and qualify the impacts of disturbance on sediment C stocks, and (3) assess the role of ecosystem restoration and connectivity in cross-ecosystem C sequestration. We quantified total C stocks and spatial variability across a data-deficient region of southeast Australia, and estimated emissions associated with historical ecosystem loss. Historical losses of blue C ecosystems in the region since European settlement were associated with C stocks 1.6 x higher than those of existing blue C ecosystems in the region, along with the loss of ongoing sequestration, suggesting substantial potential emissions with ecosystem loss. Drivers of observed C stock variability were identified through the use of geospatial modelling, and revealed ecosystem type and geomorphological variables to be most important for predicting and mapping C stocks. Through ongoing research at the Long-term Ecological Research site in the Virginia Coast Reserve, featuring the world’s largest successfully restored seagrass meadow, we are investigating the influence of seagrass C export on nearby marshes of the barrier islands. These results will be
importing for quantifying the role of allochthonous C in blue C ecosystems, which is not currently credited under most C accounting programs.

**Session 2: Behavioural Ecology 1**

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

**NOVEL APPLICATION OF RFID MARK-RECAPTURE ENABLES MONITORING OF PISMO CLAM (TIVELA STULTORUM) MOVEMENT** *(YOUTUBE)*

Sean Bignami¹; Briana Bernal ¹; Nancy Caruso ²

¹- Concordia University Irvine ²- Get Inspired, Inc.

Pismo clam (*Tivela stultorum*) populations in California once supported iconic commercial and recreational fisheries, but population declines have reduced present-day exploitation to a niche recreational fishery. Although this species may benefit from conservation efforts, a limited understanding of Pismo clam ecology makes it difficult to contextualize how populations might respond to conservation techniques. We are using a novel application of radio frequency identification (RFID) mark-recapture techniques to address one area of ecological uncertainty: the movement patterns of adult Pismo clams. Our ongoing pilot study includes over 40 Pismo clams, each tagged with an external RFID tag, released into their native intertidal beach habitat, and relocated to track their movement over days, weeks, and months. Relocation has been successful; the majority of individuals were relocated after 15 days and 50% of individuals were relocated after 6 weeks. Excavation of a subsample of clams demonstrated 100% viability 2 weeks after release. The total distance moved by individual clams has been highly variable, ranging from negligible to tens-of-meters over the duration of days to weeks. We plan to follow this initial success by addressing several challenges, including logistical limitations to the total searchable area and uncertainty about the fate of clams that are not relocated. Ultimately, these data will help us to better understand the magnitude, consistency, and circumstances associated with Pismo clam movement and may help inform conservation efforts.

**PREDATOR FORAGING BEHAVIOR AND DIET VARIATION IN A PATCHY PREY COMMUNITY** *(YOUTUBE)*

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*Oregon State University*

Differences in predator foraging behaviors can alter individual interactions with their environment, and variation across individuals can impact important ecological processes. Optimal search strategies for a foraging predator depend on the abundance and predictability of prey. While individual differences in foraging behavior by prey or habitat type have undergone much study, how individual predator movement behaviors depend on their degree of individual diet specialization is less understood. Here, we track individual intertidal predatory whelks *Nucella ostrina* over a 3-month period to assess variation in individual movement patterns. We then correlate individual movement with prey microhabitat occupancy and individual diet selection to better understand how foraging decisions are made in a heterogeneous prey environment, and by individuals with different diets. We find considerable variation in individual movement patterns, microhabitat occupancy, and diet, but no evidence for relationships between foraging movement behaviors and diet specificity. We do find correlations between individual movement and feeding activity, as well as large influences of tidal cycles on movement. We hypothesize that the lack of correlation between individual diet specialization and foraging behaviors is due to high prey
productivity at the study site, making random search patterns and small foraging movements sufficiently efficient to find prey.

**TOOL USE INCREASES FORAGING SUCCESS IN SOUTHERN SEA OTTERS**

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1- American Museum of Natural History 2- Nhydra Ecological Consulting 3- Monterey Bay Aquarium 4- US Geological Survey 5- CA Department of Fish and Wildlife 6- University of California, Santa Cruz

Although it is well documented that tool use can facilitate the exploitation of resources, the fitness benefits associated with this innovative behavior are difficult to test. Using longitudinal data from 196 radio-tagged southern sea otters, we examined how variation in tool use frequency contributes to differences in foraging success (both biomechanically and energetically) and longer-term fitness between individuals. We found that individuals, particularly females, with high tool use frequency consumed harder prey items. Furthermore, we found a bi-modal relationship between tool use frequency and caloric income, revealing that not only does frequent tool use lead to greater caloric income but that non-tool using behavior serves as a viable strategy to maintain sufficient caloric requirements. Interestingly, these foraging advantages do not translate to long-term health gains as tool use frequency neither prevented tooth injury nor increased body condition. These results indicate that frequent tool users exhibit greater foraging success by gaining access to relatively harder prey, resulting in greater caloric intake.

**HIDDEN BENEATH COLD SEAS: THE IMPORTANCE OF WINTER OBSERVATIONS IN UNDERSTANDING THE DYNAMICS OF SHALLOW SUBTIDAL BENTHIC HABITATS**

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Seasonal dynamics are of fundamental importance in temperate, boreal, and arctic ecosystems where marked environmental changes from one season to another drive annual cycles of productivity and behaviour. Nearshore subtidal marine habitats are areas of high productivity, but present significant challenges for research access and most work on populations and processes there is done during the summer. This means that our knowledge of these systems relies on temporally skewed observations, which fail to include potential seasonal variability. We used two complementary techniques to gather detailed observations of the distribution, abundance and movement behavior of multiple benthic marine invertebrate species throughout the year in the boreal waters of the Gulf of Saint Lawrence (Quebec, Canada). We combined repeated SCUBA observations of subtidal communities at 2 to 14 m and acoustic telemetry to track movement of targeted species. Preliminary results show clear seasonal movement by rock crabs (*Cancer irroratus*) and indicate seasonal redistribution of mobile benthic invertebrates with shallower habitats being more occupied during spring and summer months by certain species. This study will provide key information on how observations made during summers can or should be extrapolated to other periods of the year. Given the accelerating pace of change in nearshore marine habitats, this information will be invaluable for managers and communities who rely on the annual productivity and predictability of these ecosystems as they plan for the future.

**BEHAVIORALLY-MEDIATED SPACE-USE AND FORAGING IN CARIBBEAN PARROTFISHES**

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*Florida State University
Parrotfishes are considered important herbivores on coral reefs that remove algal biomass through targeted forays on reef substrates. Territoriality is common in parrotfishes, but the role of territoriality in determining the spatial scales at which parrotfishes exert top-down control of benthic communities remains understudied. In January and May – July 2019, we conducted GPS-tracked, behavioral observations of terminal phase individuals of five common parrotfish species (Scarus vetula, Scarus taeniopterus, Scarus iseri, Sparisoma viride, and Sparisoma aurofrenatum) on the fringing reefs of Bonaire, NL. We estimated home range areas for each individual using kernel density estimation with least squares cross-validation bandwidth optimization. Mean home range size differed significantly among species (p < 0.001) and home range locations were stable through time (> 1 month). Terminal phase individuals appeared to maintain priority access to their home ranges through contests, primarily with conspecifics, suggesting that these home ranges represent territories. The proportion of time spent in these contests with other parrotfishes was negatively correlated with foraging rates. Our findings demonstrate the importance of territoriality in determining the spatial distribution of parrotfishes on coral reefs and the effect of territorial behavior on rates of foraging, with implications for the effect of parrotfishes on benthic coral reef communities.

A PREDATOR-PREY INTERACTION BETWEEN THE SYMPATRIC ASTERINID SEASTARS MERIDIASTRA CALCAR AND PARVULAstra EXIGUA

Emily McLaren*; Maria Byrne

The University of Sydney

A novel predator-prey interaction occurs between the asterinid seastars Meridiastra calcar and Parvulastra exigua, that are sympatric on the shores of southeast Australia. Meridiastra calcar inhabits the lower shore, whilst P. exigua occupies the mid to high shore. These species can co-occur in the mid-intertidal. We characterised the interaction between the two species to determine the mode of cue that underlies the escape response in P. exigua and to determine if M. calcar actively navigates toward P. exigua as prey. Parvulastra exigua exhibited a distinct fleeing response when they encountered M. calcar. The velocity and direction of this escape response depended on the mode of cue. Physical contact with M. calcar resulted in a 1113% increase in velocity from basal locomotion. Water conditioned by M. calcar (chemosensory cue only) also elicited an increase in velocity but not by the same magnitude. The escape trajectory of P. exigua was most linear (180°) when contacted with M. calcar. Meridiastra calcar did not navigate toward P. exigua in choice chamber experiments and this was not altered if P. exigua had been damaged. These results suggest that the P. exigua escape response is strongly chemosensory and is accentuated by physical touch from M. calcar. The detection and avoidance of chemosensory cues emanating from M. calcar in the lower intertidal may influence the behaviour of P. exigua to remain higher on the shore.

SARS-COV-2 AND LARUS OCCIDENTALIS: HOW THE CORONAVIRUS PANDEMIC HAS AFFECTED WESTERN GULL FORAGING BEHAVIOR IN MONTEREY BAY

† Munro-Kennedy, S.G.1; Bergsma, G. 2

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Western gulls (Larus occidentalis) are known for being opportunistic feeders and are often considered a nuisance species as they are frequently found scavenging in trash and begging humans for food. Despite being prevalent in Monterey Bay, little is known about their natural foraging behaviors. Studies have shown that Ring-billed gulls (Larus delawarensis), a species often found with Western gulls, can get much of their food from people at parking lots, and increased
consumption of human food and decreased consumption of fish by a population of Glaucous-winged gulls (Larus glaucescens) has resulted in long term decreases in egg volume and clutch sizes. Dependence on human food can, therefore, be important to gull populations in urbanized areas, with changes in human behavior potentially affecting gull ecology. With the current SARS-CoV-2 pandemic, human access to and use of beaches has changed. We investigated how these changes affect the foraging behavior of Western gulls and their food sources along the Monterey Peninsula. Focal samples have been conducted at 12 sites since the 10th of November 2019, and include data from before the COVID outbreak and after. We found a significant difference in the behavior of Western gulls as well as their food sources among these time periods. Following the Shelter-in-Place, Western Gulls foraged more on natural food sources than they did prior to the order. This notable change in behavior and diet may impact their fecundity. Further studies are needed to determine how human food affects Western Gull physiology and reproduction.

CHARACTERIZATION OF BEHAVIORAL PATTERNS IN PISMO CLAMS (TIVELA STULTORUM) VIA POSITION SENSING WITH A MAGNETIC FIELD (YOUTUBE)
† Savannah Neu*; Jori Paradis; Sean Bignami

Concordia University Irvine

The Pismo clam (Tivela stultorum), a once abundant species native to Southern California, is now potentially rebounding from a sharp depletion in their populations throughout the twentieth century. Much remains unknown about the present-day ecology of the Pismo clam, including their behavioral ecology. We applied a sensor-based method for measuring Pismo clam gaping behavior to help elucidate their baseline behaviors and biological rhythms. A Hall Effect sensor system was implemented by applying a Hall sensor to one valve and a rare-earth magnet to the opposite valve of the Pismo clam. The sensor exerted a voltage output dependent on the proximity of the magnetic field, allowing for continuous proxy determination of the shell-gaping position while under the sand. A sample of 6 Pismo clams were monitored in an outdoor controlled environment over the course of 4 weeks. No clear biological rhythms were observed for any individual or between individuals. However, we observed 6 common behaviors exhibited by all the clams; these behaviors were designated as filtering, burrowing, resting, periodic bursts of rapid partial closing, transitioning between open to closed, and complete closing. This information provides a first step toward an improved understanding of Pismo clam behavioral ecology and will serve as a foundation for the continued study of their behavioral patterns.

Session 3: Evolutionary Biology 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

POPULATION GENETIC STRUCTURE OF THE CALIFORNIA HORN SHARK (HETERODONTUS FRANCISCI) (YOUTUBE)
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University of Hawaii at Manoa

Assessing connectivity among populations of marine organisms is critical to the development and implementation of conservation measures. To date, population genetic studies in sharks have focused primarily on large-bodied, highly mobile species, while smaller, coastal species with limited dispersal potential and small range sizes have received little attention by comparison.

The California horn shark (Heterodontus francisci) is a small, benthic shark inhabiting the East-Pacific coastline from California to Mexico. This species is known to maintain small home-ranges as
adults and exhibit high levels of site-fidelity. To assess connectivity in H. francisci across its range, we obtained tissue samples from 14 sites ranging from Santa Barbara, CA to Bahia de Los Angeles, Baja California, Mexico, including Santa Catalina Island (CA), Anacapa Island (CA), Santa Cruz Island (CA), and Isla Guadalupe (Baja California, MX) \( n = 318 \). We then sequenced a 724-bp region of the mitochondrial control region and ran an AMOVA, as well as pairwise \( \Phi_{st} \) comparisons among populations.

The AMOVA revealed significant population structure across the entire range of H. francisci \( (\Phi_{st} = 0.324, p < 0.0001) \). Pairwise comparisons revealed strong genetic structure between the southern Channel Islands and the California mainland \( (\Phi_{st} = 0.131-0.595, p < 0.05) \), which are separated by only 20 to 35 kilometers of open water. Our analyses also revealed evidence of a demographic split between populations to the north and south of Punta Eugenia, Baja California Sur, Mexico.

**EVOLVE AND RESEQUENCE FOR EGG SIZE IN A SEA SLUG WITH STRIKING LIFE-HISTORY PLASTICITY (YOUTUBE)**

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*UC Davis*

Developmental mode consists of suites of phenotypic and behavioral traits that can influence micro- and macro-evolutionary patterns and processes including gene-flow, local adaptation, and speciation and extinction. In marine invertebrates there are typically two discrete types of developmental mode: large non-feeding, non-dispersive lecithotrophic larvae and small feeding and highly dispersive planktotrophic larvae. A few species exhibit intraspecific variation for developmental mode (termed poecilogony) and provide powerful systems to identify the minimum number of genetic changes and environmental influences that underlie developmental mode evolution. I used an evolve and resequence approach to identify the genomic response to selection for increased proportions of lecithotrophy in the poecilogonous sea slug Alderia willowi. Lecithotrophy increased from 36% to 60-70% after 5 generations of selection in low (16 ppt) and high salinity (32 ppt) across 6 replicate populations. In a genome-wide test of association I found 10 loci on 8 scaffolds to be associated with developmental mode, showing the polygenic nature of developmental mode in A. willowi. Sequencing the replicate lines after selection I found a significant change in allele frequency for these loci that was shared across replicate lines. These results show that there is standing genetic variation for developmental mode in A. willowi that may be maintained via phenotypic plasticity.

**UNLOCKING THE EXOME: EXPLORING DE NOVO ASSEMBLY OPTIONS FOR CAPTURE SEQUENCING (YOUTUBE)**

† Green, J.M.*; Puritz, J.B.

*University of Rhode Island*

Sequencing the genomes and transcriptomes of non-model organisms has transformed the way ecologists and evolutionary biologists study the marine environment. A major challenge in bioinformatic studies is building robust reduced representation assemblies in the absence of complete, well annotated genomes. High rates of genetic polymorphism and genomic rearrangements within shellfish populations pose difficult challenges in sequencing. New sequencing methods, such as Expressed Exome Capture (EecSeq), present a unique approach to these challenges. EecSeq has the potential to be applied to any organism, if loci can be efficiently assembled directly from capture reads. This study sought to test a de novo assembly and assessment pipeline for EecSeq studies using sample reads from the eastern oyster (Crassostrea
virginica) to build an exome assembly. Four transcriptome assembly programs (Oases, rnaSPAdes, Trans-ABySS, and Trinity) and one genome assembly program (SPAdes) were utilized to build oyster exomes. To categorize these exome assemblies the number of transcripts, N50 values, annotation rates, BUSCO, and read mapping were used. No single assembly outperformed all others across assessment parameters. The Oases assembly had the highest N50 values (2147 bp) but exhibited an elevated annotation (169,198 genes); while Trans-ABySS annotation (40,964 genes) was closest to the predicted number of oyster genes (55,531 genes) and showed the most complete BUSCO percentages. All EecSeq de novo assembly reads mapped reflected the proportional abundance of genes identified in the easter

GEOGRAPHIC VARIATION OF VENOM GLAND TRANSCRIPT EXPRESSION IN THE COTTONMOUTH SNAKE (AGKISTRODON PISCIVORUS) (YOUTUBE)
† Lawrence, K.C.*; Colston, T.J.; Holding, M.L.; Rokyta, D.R.
Florida State University

Organisms must adapt to their environment to survive. Selection pressures that vary with geography such as predation and resource availability select for traits that convey fitness, which may lead to speciation. One such trait is venom production in North American pit vipers. Venom is a complex mixture of toxin and nontoxin proteins that are used in prey capture and defense. It is under heavy selection pressure due to its direct influence on individual survival, thus differences in venom composition among populations may be associated with geographic variation. The Cottonmouth, Agkistrodon piscivorus, is a venomous snake that is found throughout the Southeastern United States. A semiaquatic pit viper, A. piscivorus generally resides in or around the water and opportunistically feeds on local prey. There are three geographically defined subspecies (Western, Eastern, Florida), and two putative species (Continental and Florida). We hypothesize that variation in venom composition should reflect these proposed species classifications as A. piscivorus becomes more specialized to their local environment. We collected venom gland tissue and whole venom samples from nine individual A. piscivorus from across their geographic range. We used quantitative transcriptomic and proteomic approaches to determine the effect of geographic selection pressures on toxin abundance. We found that the phospholipase A2 (PLA2) gene family was consistently the dominant component of A. piscivorus venom, but the extent of its dominance varied among subspecies, providing evidence for speciation.

BIOGEOGRAPHIC INSIGHTS INTO THE EVOLUTION OF COLONIALITY IN ASCIDIANS
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While there are many descriptions of latitudinal gradients in diversity in different clades, fewer studies assess the mechanisms underlying these patterns. For example, while total ascidian diversity increases toward the equator, it is often observed that the ratio of colonial to solitary species is higher in the tropics and subtropics relative to higher latitudes. Using publicly available species occurrence data from OBIS and GBIF we found that the latitudinal coloniality diversity gradient is robust and exists independently of any longitudinal patterns or latitudinal variation in coastline length, sampling effort, and occurrence depth. The pattern is largely driven by a strong increase in the number of colonial species at low latitudes. Many of the proposed hypotheses for this pattern suggest that increased competition and predation in the tropics could favor colonial ascidians because of their superior ability to survive competition and predation. If such forces were
acting in ecological time, this should create a latitudinal gradient in the relative abundance of colonial versus solitary species, not just in the diversity of the two forms. When we analyzed species abundance data from two large experimental networks, we found that the relative abundance of colonial versus solitary ascidians, as measured by frequency of occupation of experimental tiles (but not percent cover), peaked in the tropics, consistent with this ecological hypothesis. Our findings indicate the need for more rigorous testing of the mechanisms underlying broad biogeographic patterns.

**BIPARENTAL INBREEDING MIRRORS RATES OF SELF-FERTILIZATION IN A SPERMCASTING INVERTEBRATE (YOUTUBE)**
† Olsen, K.C.*; Levitan, D.R.

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Through its effects on the structure of genetic variation, the degree to which individuals inbreed or outbreed has a profound influence on evolution. Yet, our understanding of the factors contributing to the prevalence of inbreeding outside the context of self-fertilization remains largely incomplete. Compared with the many theoretical and empirical assessments of self-fertilization in hermaphroditic plants and animals, the causes and extent of inbreeding among relatives (biparental inbreeding) is not well understood. To investigate this, we evaluated the magnitude of biparental inbreeding and its population-level variation in a spermcasting ascidian (*Lissoclinum verrilli*) along limestone and artificial reefs in the northeastern Gulf of Mexico. We found that mating among relatives was common, and that the strength of biparental inbreeding mirrored rates of self-fertilization reported for terrestrial seed plants and aquatic snails. Individuals tolerated inbreeding rather than actively avoiding or preferring it, resulting in associations between the magnitude of biparental inbreeding, the degree of relatedness among colonies at a location, and the historical effective size of the population. The results suggest that the magnitude of biparental inbreeding in spermcasting invertebrates can vary to a similar extent as rates of self-fertilization in highly inbreeding species. We suggest that future work assessing variation in the mechanisms that regulate the ability to inbreed will provide valuable insight to the evolution of biparental mating systems.

**ASSESSING THE EVOLUTIONARY RESPONSE OF EASTERN OYSTER LARVAE TO EXPOSURE COASTAL ACIDIFICATION AND SEWAGE EFFLUENT: A CASE STUDY (YOUTUBE)**

Puritz, J.B.*; Harvey, J.A. 2; Lotterhos, K.E. 3

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Although coastal organisms experience natural and anthropogenic stressors simultaneously across multiple spatial and temporal scales, the synergistic effects of multiple stressors are largely unknown. In urbanized estuaries, coastal acidification (CA) can be caused by eutrophication and is strongly associated with a second anthropogenic stressor, sewage effluent (SE). SE can cause acidification locally by increasing nitrogen loads and stimulating algal and microbial production of CO₂. The physiological effects of CA and SE have been well characterized separately but have never been examined together in early life history stages when organisms are most sensitive to stressors. Additionally, results from many studies have not been examined in a mechanistic framework, such as identifying the genes that provide resistance to multiple stressors. Here, we use multiple factorial exposures on eastern oyster larvae to characterize the effects of CA and SE on larval mortality and use expressed exome capture sequencing to detect which genetic variants lead to resistance and
potential adaptation. Results indicate that CA, SE, and CASE induce clear changes in the allelic composition of larval pools and that the CASE treatment did not represent a composite of the CA and SE treatment. Higher gene ontologies for outlier loci appear to be related to chemical and stress response, supporting the possibility of adaptive resistance to multiple stressors.

Session 4: Physiological Ecology 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

TEMPORAL DYNAMICS OF MULTIPLE STRESSOR EFFECTS ON CRASSOSTREA VIRGINICA IN GALVESTON BAY (YOUTUBE)
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While there are studies on the effects of multiple environmental and anthropogenic stressors on Eastern oysters (Crassostrea virginica) in the Gulf of Mexico, few have focused on temporal dynamics of stressors, though prior stresses could influence responses to later ones. In Galveston Bay, the hurricane season begins in May, following mild spring water temperatures, but continues through late summer months, when water temperatures can reach 32°C. Here, we asked if oysters respond differently to hurricane-level low-salinity stress after periods of elevated late summer temperatures relative to more standard, early-season conditions. We exposed newly settled oyster spat to early-season (24°C) or late-season high temperatures (32°C) for one month followed by an acute low salinity (1 ppt) disturbance for 10 days (versus control). The majority of oysters (93%) exposed to high temperatures for a month before low salinity exposure survived. However, those that were exposed to low-salinity without prior high-temperature conditioning experienced lower survivorship (71%). When stressors were imposed simultaneously with no prior conditioning (high temperatures and low salinity during the 10-day event), only 23% of oysters survived. Results suggest that incorporating temporal dynamics, rather than simply crossing multiple stressors simultaneously, can have important consequences for our understanding of likely population impacts.

QUANTIFYING INTRASPECIFIC VARIATION IN THERMAL PERFORMANCE TRAITS OF THE SALT MARSH GASTROPOD LITTORARIA IRORATA
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University of Georgia Odum School of Ecology

Physiological processes influence how individuals perform in various environmental contexts. The basis of such processes, metabolism, scales nonlinearly with both body size and temperature, with many physiological processes described by a thermal performance curve (TPC). TPCs are often assumed to be invariant across populations of the same species, despite a handful of studies that have demonstrated intraspecific variation in thermal traits. To scale up results from individual performance to population traits, we therefore need to consider three components: 1) population size structure (intrapopulation variation in size); 2) environmental context (interpopulation variation in temperature); and 3) population specific parameters of the TPC. Here, we estimate parameters of the TPC in the salt marsh gastropod, Littoraria irrorata. First, we quantify how respiration rates scale with both temperature and body size in Littoraria. Next, using feeding rates, we quantify how these relationships (i.e., parameters in the TPC) vary among Littoraria populations that occur along a latitudinal gradient. Our work suggests that the mass-scaling of Littoraria feeding rate varies across sites, thus highlighting the importance of considering both intrapopulation size structure and variation in physiological allometry when attempting to predict how temperature
change will translate into physiological responses with the potential to influence consumer-resource interactions.

**THE META-ORGANISM RESPONSE OF A GENERALIST CORAL SPECIES TO HEAT STRESS** *(YOUTUBE)*

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Bleaching events in the marine environment are now occurring globally, with the frequency and severity of these events increasing. However, the capacity for corals to adjust their bleaching thresholds in response to increasing ocean temperatures remains unknown. As changes in environmental structure occur under climate change, widespread generalist species such as *Pocillopora damicornis* may be better able to acclimatize to new environments than specialist species existing within small “niche” ranges. Here we investigate the impact of early bleaching thermal stress exposure on the meta-organism responses of *P. damicornis*. Using mesocosms to recreate warming scenarios previously observed at Heron Island, Australia, we show that *P. damicornis* symbiont densities and photophysiological parameters decline at a similar rate under thermal stress regardless of length of pre-stress period. Interestingly, we find that the *P. damicornis* microbiome remains stable over time irrespective of the degree of thermal stress accumulation. Given that *P. damicornis* is targeted as a low-cost species for use in restoration efforts on degraded coral reefs, it is imperative to understand the capacity of this coral to withstand bleaching events. The widespread distribution of environmental generalist coral species as a whole suggests their potential contribution to coral reef structure under future climate conditions and as such the biology, physiology and bleaching responses of these corals need to be determined.

**REALISTIC FIELD MANIPULATIONS TO SIMULATE FUTURE CLIMATE CONDITIONS MODIFY SEAWEED PHOTOSYNTHETIC PERFORMANCE** *(YOUTUBE)*

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1-Dept. Ecology & Evolutionary Biology, UC Irvine 2- Dept. Ecology & Evolutionary Biology, UC Santa Cruz 3- Dept. Biology, San Diego State University

Despite the confidence with which climate modelers provide increasingly bleak prognoses for future climate change, ecologists lack key biological data necessary to forecast species’ responses to predicted changes in temperature and CO₂ levels. We conducted in situ field manipulations of temperature and CO₂ in tide pools to assess responses to simulated future conditions. We deployed custom-designed heaters and CO₂ generators which elevated daytime temperatures by 1.6 degrees C and reduced tide pool pH by 0.5 units. We maintained these climate manipulations for 2.5 months during the summer of 2020 on the rocky shoreline of Japonski Island, Sitka, Alaska. After ending the climate manipulations, we returned to experimental and control pools and measured photosynthetic performance of the seaweed *Neorhodomela oregona*, which was found in all of the tide pools at our study site. We quantified the electron transport rate (ETR) associated with photosystem II – a proxy for carbon fixation – as a function of irradiance levels and found that seaweeds in climate-manipulation pools had lower photosynthetic efficiency at low light levels (alpha) and higher photosynthetic performance at high light levels (maximum ETR) than those in unmanipulated pools. Our results from an in-situ field experiment suggest that predicted changes in temperature and CO₂ levels could alter the photophysiology of seaweeds.
Species that form biogenic habitat, such as bivalves, corals, kelps and seagrasses are well known modifiers of their local flow environment, providing low-flow refugia for a diversity of species. The benefits of reduced flow for densely aggregated species such as mussels include reduced dislodgement risk and energetic cost to produce strong byssal attachments. Flow reduction can be a liability, however, if flow is not sufficient to flush the interstitial spaces and steep, metabolically-driven concentration gradients develop. Motivated by recent laboratory findings that mussel byssal attachment is weakened by low pH (< 7.6) and low dissolved oxygen (DO, <2 mg/l), and field observations of these conditions within mussel aggregations, we conducted laboratory flume and field assays to quantify flow effects on the microscale chemical environment where the byssal threads are produced. Specifically, we placed small aggregations of mussels (Mytilus spp.) in a flume under a range of flow speeds and measured DO concentration within the aggregation relative to ambient. Mussels in aggregations, which mimicked monolayer beds or aquaculture long lines, reduced microscale DO conditions at flow speeds <5 cm/s. Similar results were observed in preliminary field trials and suggest corrosive chemical microclimates (e.g., low oxygen, low pH) will be most extreme in low flow, high temperature conditions, especially for dense aggregations of mussels with large biomass and/or high respiration rates, and will negatively impact mussel beds and the diverse biological communities they support.

ASSESSING THE EARLIEST STAGES OF SHELL MINERALIZATION IN THE BARNACLE AMPHIBALANUS AMPHITRITE

Barnacles are conspicuous members of marine intertidal and biofouling communities. They tenaciously adhere to nearly any inert surface in the marine environment, including ship hulls, aquaculture facilities, and other marine structures, resulting in a tremendous cost and performance burden for maritime industries. While significant progress has been made in recent years on barnacle adhesive mechanisms, less is known about the mineralized shell formation process, particularly in newly metamorphosed juveniles. Here, we explore the earliest stages of shell development, tracking individual barnacle, Amphibalanus amphitrite, cyprid larvae as they undergo metamorphosis through to the to juvenile stage. Using a combination of scanning electron microscopy (SEM), confocal microscopy, and Raman spectroscopy, we show that juvenile barnacles initially secrete mesh-like organic shell plates, which are not fully mineralized until 48 hours post-metamorphosis. As such, juvenile barnacles are likely to be particularly susceptible to predation and mechanical stress during the first 48 hours after metamorphosis. On-going efforts will refine the timeline of mineralization in juvenile barnacles and link structure, composition, and mineral phase to mechanical properties of the shell. This work was funded by the US National Science Foundation.

The zombification and revival of purple urchins (Strongylocentrotus purpuratus) in response to food availability

† Dolinar, D.P.; Edwards, M.S.
Purple sea urchins (Strongylocentrotus purpuratus) are herbivores who inhibit rocky reefs from British Columbia to Baja California. When top down pressure decreases, often by means of a decrease in predator abundance, purple sea urchins increase grazing intensity and are capable of consuming all of the macroalgae within a kelp forest. This has resulted in the formation of urchin barrens throughout the large portions of their range. In barrens, urchins experience starvation, causing physiological changes such as a decrease in gonad mass and, over time, a complete resorption of their gonad tissue. We examined how S. purpuratus responds metabolically when deprived of food for long periods of time. This was done by comparing respiration rates of urchins who had access to food and urchins who have been starved for seven and 14 weeks. We observed a significant decrease in oxygen consumption after the urchins were starved, indicating decreased metabolic activity. After 14 weeks of starvation, the urchins were again fed for seven more weeks, which resulted in a revival of their metabolic activity that matched pre-starvation levels. In addition, we sampled urchins from Stillwater Cove, CA from areas of high macroalgal density as well as barren areas but found there to be no difference in urchin metabolic rates between the two areas. Our results suggest that when facing starvation, urchin metabolic rates significantly decrease. However, if they periodically receive food, they can sustain moderate levels of metabolic activity.

EFFECT OF LONG-TERM EXPOSURE TO MULTIPLE STRESSORS ON BIOCHEMICAL PATHWAYS OF THE BLUE MUSSEL, MYTILUS EDULIS. (YOUTUBE)
† Draluck, M.C.; Zippay, M.L.

Sessile marine invertebrates in the rocky intertidal zone live in a dynamic environment with daily tidal fluctuations, temperature changes, predator pressures and differences in food availability. Due to these fluctuations, the intertidal zone has become an ideal system to study the effects of anthropogenic climate change. Exploring how these organisms respond to stress demands a closer investigation into their cellular and biochemical pathways, and whether there are energetic strategies involved in enabling them to survive these perturbations. Little is known about the long-term effects of multiple stressors on the ecologically important blue mussel, Mytilus edulis. In this study, various subcellular pathways were measured during a multifactorial design by combining food availability (fed or starved), increased water temperature (ambient or +2 °C), and risk of predation (predator cue or lack thereof). Mussels sampled across a 12-week period were measured for aerobic and anaerobic capacity by measuring activity and relative abundance of two enzymes (citrate synthase and malate dehydrogenase), and abundance of energy storage (glycogen). Results may show interactive effects of multiple stressors have an antagonistic impact on the overall physiology, greater than the sum of individual stressors, or perhaps less likely, a synergistic impact, disrupting the harmful effects of individual stressors impacts. This study aims to elucidate the mechanism of survival strategies over chronic exposure to stressors in M. edulis, an important, economically valuable, ecosystem engineer.

Session 5: Population Biology and Ecology 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

TRANSGENERATIONAL PLASTICITY CAUSES DIFFERENCES IN UV-TOLERANCE OF INTERTIDAL AND SUBTIDAL POPULATIONS OF THE PURPLE SEA URCHIN (YOUTUBE)
† Alvarez, Y.*; Adams, N.L.

California Polytechnic State University, San Luis Obispo
Planktonic larvae of marine organisms are increasingly being exposed and required to respond to a changing physical environment. To answer how populations of invertebrates residing at different depths prepare their offspring to cope with different levels of ultraviolet radiation (UVR), we collected adult purple sea urchins, *Strongylocentrotus purpuratus*, from four sites (two intertidal and two subtidal (~15 m deep)) to compare UV tolerance in offspring. UV irradiance measurements at collection sites showed UVA and UVB were low or absent in subtidal sites compared to intertidal sites. We found that offspring from intertidal populations experience a less severe developmental delay when exposed to environmentally relevant levels of UVR (using artificial lighting) than offspring from subtidal populations. The mean percent cleavage delay for UV-treated embryos relative to the controls was 16% (± 2.3 SE) for intertidal sites and 21% (± 2.7 SE) for subtidal sites. This suggests that environmental UV cues or additional cues experienced by intertidal mothers may prepare offspring to resist effects of UV exposure during early development. To further understand differences in biochemistry of the eggs released from mothers of different populations (i.e. differences in maternal investment), we assessed differences in protein abundance among batches of eggs. We identify a range of candidate proteins involved in various cellular processes such as cell cycle regulation, signaling and transport, oxidative stress and metabolism that may help developing embryos cope with UVR stress.

**POPULATION RESPONSES TO INCREASED BULL KELP DENSITY AND EXTENT ON CALIFORNIA’S NORTH COAST** *(YOUTUBE)*

Belak, Carolyn A.; Tissot, Brian; Craig, Sean

*Humboldt State University*

Kelp forests on California’s north coast have undergone major declines since experiencing the 2014 marine heatwave following the onset of seastar wasting disease in 2013. The rapid shift from biodiverse kelp habitat to urchin barren along most of the coast has elicited growing concerns about ecosystem health and long-term consequences. However, after favorable oceanographic conditions in early 2020 promoting bull kelp recruitment and growth, kelp bed density and extent on the north coast in summer 2020 was the greatest seen in the past 7 years. Although early in its recovery, the return of this ecosystem has implications for the organisms using kelp as essential habitat. Here we will address changes seen in fish assemblages, invertebrate biodiversity, and urchin and abalone populations at three sites along the northern California coast between 2019 and 2020, using data from a subtidal long-term monitoring program. All three sites experienced increases in kelp stipe density on survey transects but differed in their population responses to these increases. Results from this monitoring effort could help to understand early effects of the observed upward trend and provide insight to the relative strength of resilience of northern California kelp ecosystems.

**SEX-DEPENDENT EFFECTS OF LOCAL ADAPTATION ON THE THERMAL PHYSIOLOGY OF TIGRIOPUS CALIFORNICUS ACROSS A LATITUDINAL CLINE** *(YOUTUBE)*

† Bogan, S.N.1; Meneses, M.J. 1; Kozal, L.C. 1; Albrecht, A.M. 2; Hofmann, G.E. 1

1- University of California, Santa Barbara 2- Vassar College

Sexual dimorphism and local adaptation are distinct sources of intraspecific phenotypic divergence whose interactions are theorized to affect adaptation. Positive cross-sex genetic correlations should hinder adaptation when sexes’ phenotypic optima vary at different rates over a species’ range or aid adaptation when sex-specific optima covary. Thermal physiologies in ectotherms commonly exhibit sexual dimorphism and adaptive interpopulation variation, but the extent to which sex-specific effects influence local adaptation to thermal environments is unclear. Populations of the intertidal
copepod *Tigriopus californicus* are locally adapted to thermal environments across North America’s Pacific coast and can display sexual dimorphism in thermal tolerance. We quantified body size, thermal tolerance, and metabolic responses to thermal stress in male and female *T. californicus* from four populations across California. Each trait varied as a function of latitude. Latitudinal effects were significantly larger among females, causing sexual dimorphism in thermal physiology to increase in northern populations. The northmost population showed reduced fecundity consistent with the prediction that differential selection between sexes should hinder adaptation and fitness. By integrating metabolic thermal performance curves with time series temperature data, we show that northern females were indeed likely to experience greater thermal stress *in situ* than male and southern conspecifics. Our results suggest that sexual dimorphism may influence local adaptation to thermal environments.

Freeze tolerance of poleward-spreading mangrove species weakened by soil properties of resident salt marsh competitor *(YOUTUBE)*
Byers, J. E. 1*; Blaze, J. A. 1; Smith, R. S. 1; Peng, S. 2; Chen, E. 2

1- University of Georgia 2- Sun Yat-sen University

As climate change shifts species to higher latitudes, soil communities could affect plant range expansion, particularly if they influence plants’ responses to climate, such as freeze tolerance, that feedback to affect expansion. We used the northward range expansion of the black mangrove, *Avicennia germinans*, into a system dominated by marsh cordgrass, *Spartina alterniflora*, in northern Florida to study how the novel soil environment (i.e. *S. alterniflora* soil) affects mangrove fitness, susceptibility to cold stress and the colonization of mutualist fungi. We quantified abundance of root mutualistic fungi in mixed marsh-mangrove habitat and found 2 times higher dark septate endophyte (DSE) colonization of *A. germinans* roots and 3 times higher fungal spore density in *A. germinans* soil compared to *S. alterniflora* roots and soil. Next, in the lab we tested the effects of steam-sterilized and live soils from *A. germinans* and *S. alterniflora* on the growth, condition, fungal colonization and freeze tolerance of *A. germinans* seedlings. Seedlings in steamed *S. alterniflora* soil treatments had 50%–65% survival after freezing, compared to 0% survival in treatments with live *S. alterniflora* soil. *S. alterniflora* soil could impede mangrove establishment in salt marsh communities. As climate warming gradually allows *A. germinans* to displace *S. alterniflora*, the rhizosphere could become increasingly hospitable to *A. germinans*. Our work suggests the soil community associated with resident species mediates climatic stressors to affect expansion success.

**ASSESSMENT OF THE INTERTIDAL GREEN ABALONE POPULATIONS OF ORANGE COUNTY**
Steers, J. 1*; Caruso, N.L. 2

1- affiliation not listed 2- Marine Biologist, Get Inspired, Inc

Abalone populations worldwide have been in decline for many decades due to overfishing, illegal harvest, disease, and habitat degradation. California once supported fisheries for five species of abalone (black, green, pink, red, white), which now are all closed. Green abalone, *Haliotis fulgens*; *Philippi*, are native to southern California and range from Point Conception, California, USA, to Magdalena Bay, Baja California, Mexico, and include the offshore islands. The green abalone is listed as a federal Species of Concern (NOAA) and is estimated to be at less than 1% of its baseline density. In an ongoing effort for species restoration, we have been studying the existing wild population in Orange County California. This long-term monitoring program has been developed to assess size/density, recruitment events, and to determine the preferred habitat for juvenile abalone. The rocky reefs of Orange County lack the characteristic cobble, boulder that is associated with juvenile
abalone habitat. We have conducted 49 surveys, over 3 years in every rocky tidepool area on our 42-mile coast. We surveyed 3760 $m^2$ and found 324 green abalone ranging in size from 20mm to 220mm with a density of 0.09/m$^2$ below the minimum viable density of 0.2 individuals/m$^2$. In 2017, at the beginning of our survey period, we found an abundance of 20-80mm abalone indicating a recruitment event had taken place in the previous 2 years.

**Spatial patterns of adult blue crab abundance across a restored seagrass landscape** (YOUTUBE)
† Cheng, S.L.; Cornish, M.R.; Hardison, S.; Smith, R.S.; Tedford, K.N.; Castorani, M.C.N.

*Department of Environmental Sciences, University of Virginia, Charlottesville, VA*

The blue crab (*Callinectes sapidus*) is an ecologically and economically important mesopredator that supports the most valuable fishery in the Chesapeake Bay. As such, understanding blue crab distributions is useful for blue crab fisheries management, particularly as warming temperatures may lead to changes in habitat. We examined the spatial patterns of blue crab abundance at local and landscape scales across restored seagrass meadows in the coastal bays of Virginia’s Eastern Shore, site of the Virginia Coast Reserve Long-Term Ecological Research project. Specifically, we explored how local-scale seagrass meadow variables and landscape-scale habitat connectivity variables affect blue crab abundance and distribution. During the summer of 2019, we collected crabs using baited commercial traps at 24 locations distributed across seagrass meadows in four coastal bays. Sampling was repeated at each location five times. We recorded sex, maturity, size (carapace width), molt stage, and reproductive stage (females only) for each crab. Water quality variables and seagrass density were also measured at each site. We found that blue crab abundance varied strongly among the bays. Adult blue crabs were more abundant in areas of sparse seagrass compared to dense areas. Conversely, the proportion of egg-bearing mature females increased with seagrass density and was higher along meadow edges compared to the centers. These results suggest that the management and restoration of seagrass meadows may alter the spatial distribution of blue crabs, with implications for fisheries management.

**THE TALKING DEAD: INSIGHTS FROM TWENTY YEARS OF MARINE MAMMAL STRANDING RESPONSE IN MONTEREY COUNTY, CALIFORNIA** (YOUTUBE)

*Moss Landing Marine Laboratories, San José State University*

Marine mammal strandings provide a unique opportunity to collect morphological, taxonomic, and life history data from otherwise elusive species. Stranding records can indicate changes in mortality patterns, inform species range assessments, and provide insights into ocean health. The productive waters of Monterey Bay, CA are home to a diverse and abundant assemblage of marine mammals that are monitored by the Moss Landing Marine Laboratories Marine Mammal Stranding Network. To define longterm stranding patterns in this region, we analyzed data from all documented deceased pinnipeds and cetaceans (n=2,617) in Monterey County from 2000-2019. During this 20-year period, a total of 25 species (6 pinniped and 19 cetacean) were observed, with pinnipeds (n=2,418; 92.4%) stranding more frequently than cetaceans (n=199; 7.6%). The California sea lion (*Zalophus californianus*, n=1,776; 67.9%) was the most frequently stranded species, followed by the harbor seal (*Phoca vitulina*, n=402; 15.4%), northern elephant seal (*Mirounga angustirostris*, n=111; 4.2%), and harbor porpoise (*Phocoena phocoena*, n=103; 3.9%). Stranding numbers varied seasonally and annually, with seasonal peaks in the summer and annual peaks corresponding with warming events such as El Niño and “The Blob”. Our results emphasize the importance of maintaining longterm records of marine mammal strandings. As climate change, anthropogenic
disturbance, and coastal development continue to alter marine habitats, such baseline data will be essential for interpreting future stranding patterns and larger ecosystem shifts.

**EVALUATING RECOVERY OF ABALONE (HALIOTIS SPP.) AT SANTA CATALINA ISLAND, CALIFORNIA (YOUTUBE)**

Estrada, A.C.¹; Steele, M.A. ¹; Rogers-Bennett, L. ²

1- California State University, Northridge 2- Bodega Marine Laboratory & California Department Of Fish And Wildlife

California’s abalone populations have been slow to recover after 22 years of fishery closure, or are not recovering at all due to recruitment failure. Recently, green abalone (*Haliotis fulgens*) have shown signs of population recovery at sites at Santa Catalina Island but populations of pink abalone (*H. corrugata*) have remained at relatively low densities. Data on green and pink abalone densities and size distributions are limited, making it difficult to assess if and how these species of concern are recovering. In this study, we use an empirical approach to quantify density, spatial distribution, and size distribution of abalone populations Santa Catalina Island to examine recovery. Green abalone density averaged 0.083 individuals per m², which is 40% of the first criterion of minimum density (0.2 per m²) for recovery in the Abalone Recovery Management Plan for California, while pink abalone density was only 0.011 per m², or at 5% of the recovery target. Both green and pink abalone met the criterion for 25% proportion of large individuals (>152 mm) in the population but not proportion of intermediate (100–152 mm) individuals (90%). These densities and size structures reveal different recovery trajectories after two decades under moratorium, which will help inform how we support restoration in these depleted abalone populations. Continued surveys are needed to assess whether fishery closure alone will allow populations to recover, or if further restoration actions are needed for successful recovery of green and pink abalone at Santa Catalina Island.

Session 6: Applied Ecology 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**INVESTIGATING THE LINK BETWEEN INDIGENOUS-LED CONTEMPORARY CLAM TENDING PRACTICES AND CLAM PRODUCTIVITY IN CANADA’S LARGEST PORT**

† Guttmann, M*

*Simon Fraser University*

Along the coast of the Pacific Northwest, clams have been a critical component to First Nations food security and cultural wellbeing for millennia. However, the past century has seen major industrialization, contamination, land alteration, and species introduction that have altered Indigenous clam-tending practices across the Pacific Northwest. The co-evolved relationship between humans and clams, existing prior to European contact on Canada’s west coast, has been recognized through multiple lines of evidence but has not yet been investigated in a contemporary industrialized ecosystem. Here, we propose to incorporate Tsleil-Waututh Nation (TWN) knowledge and priorities, alongside experimental field science and collaborative field surveys to inform contemporary clam management decisions in Burrard Inlet, home to Canada’s largest port. Specifically, we propose to: (1) quantify the ecological and social variables driving contemporary clam density, productivity and diversity; (2) experimentally test the effects of TWN clam tending practices on contemporary clam growth rates and survivorship; and (3) inform decisions about resilient TWN clam management strategies in Burrard Inlet. This work will have implications for broader social-ecological objectives held by TWN, such as increasing access to healthy wild foods.
for the community. Where traditional clam-tending practices have been adapted and revived, chronicling this change counters the erasure of indigenous peoples' connection to their lands and seas resulting from colonization.

THE SMALLEST PIECE OF THE BIGGEST FISH: EXPLORING THE WHALE SHARK EPIDERMAL VIROME (YOUTUBE)
† Hesse, R.D.†; Dinsdale, E.A.

San Diego State University

Bacteriophages are a primary driver of microbial community dynamics, and thus a key component of organismal microbiomes. The “piggyback the winner” hypothesis postulates that they provide an externally derived immune system for species with external mucous secretions. However, due to gaps in current databases, the composition of marine vertebrate viromes and the factors that shape them are largely unknown. This project aims to chip away at data deficiencies and elucidate the role viruses play in host immunity using various elasmobranchs as a study system, in particular the whale shark Rhincodon typus. Whale sharks display high levels of mucus production and a microbiome that varies in species composition based on their location. Using bioinformatics techniques to mine embedded viral DNA from microbial genomes, we have observed biogeographical patterns in the composition of whale shark viromes, as well as support for the harboring of viral strains that aid in host immunity.

Pacific Lamprey as Filter Feeders to Reduce Bacteria (YOUTUBE)
† Kalan, Parker†; Gates, Michael ²; White, Crow ³; Otte, Freddy ⁴

1- Lead Researcher, MS Candidate 2- Co-researcher 3- Advisor 4- Co-investigator, City Biologist

Water quality represents a serious concern for water resource management, ecosystem health, and recreational water use. Water quality is directly affected by fecal pathogenic bacteria abundance (Dadswell 1993, Ford and Colwell 1996, Rees et al.1998), which presents a human health hazard when in a watershed at high concentration (Kim et al. 2010). Pacific Lamprey (Entosphenus tridentatus) are an anadromous species of lamprey that have a multipartite life history. In their freshwater stage, lamprey utilize coastal creeks for spawning and rearing (Close et al. 2002). Juvenile lamprey, known as ‘ammocoetes’, reside in creeks for up to seven years, providing unique ecosystem functions during this phase of their life history (Scott and Crossman 1973; Dawson et al. 2015 ). Specifically, ammocoetes filter feed within the water column, reducing a variety of suspended detritus from the water. A 1980 study confirmed that larval lamprey feed on suspended detritus including bacteria (Moore and Mallat 1980).

Our study sought to test the hypothesis that Pacific Lamprey will reduce bacteria specifically E. coli in coastal watersheds. To test this hypothesis we created a laboratory space with controlled aquaria, then subjected Pacific Lamprey Ammocoetes to water naturally inoculated with E. coli. We found significant differences between treatment and control tanks with a quantifiable reduction in E. coli measured in tanks with ammocoetes.

MONITORING CALIFORNIA’S COASTAL BIODIVERSITY WITH CROWDSOURCED COMMUNITY-CONTRIBUTED OBSERVATIONS (YOUTUBE)
Rapacciuolo, G.¹; Young, A ¹; Esgro, M ²; Johnson, RF ¹

1- California Academy of Sciences 2- Ocean Protection Council
Crowdsourced biodiversity data contributed by volunteers, community, and citizen scientists can cover spatial, temporal and taxonomic scales difficult to achieve by other approaches. As a result, these data make up an increasingly large proportion of our overall knowledge of the global distribution of biodiversity in space and time. Our team – a collaboration between the California Academy of Sciences (Academy), the California Ocean Protection Council, and the California Department of Fish and Wildlife – is building the capacity to make use of the Academy’s ongoing community science initiatives and crowdsourced observations to understand and monitor coastal biodiversity change in order to better manage for it. In particular, relevant community science initiatives include Snapshot Cal Coast – an annual statewide effort to engage volunteers to document California’s coastal biodiversity across all of the state’s coastal counties – and iNaturalist – a technological platform, which facilitates the recording, sharing and visualization of detailed biodiversity information. In this talk, I introduce how the tens of thousands of coastal biodiversity observations generated every year via these initiatives represent our best-available real-time observatory of the California coast and can provide an early-warning system to detect significant management-relevant biodiversity changes on the California coast.

**HOW TO CHOOSE THE BEST MIX OF METHODS FOR SAMPLING BIODIVERSITY**  
(RYOUTUBE)  
Rassweiler, A.; Hernan, G.; Dubel, A.K.

*Florida State University*

Effective monitoring of biodiversity is crucial for understanding ecological dynamics, assessing human impacts, and guiding management decisions. To monitor the wide variety of life, most research programs employ multiple sampling methods, but limited resources constrain any program, and researchers must choose a few methods to implement, deciding how much to invest in each. Despite the complexity and importance of these resource allocation decisions, they are often made on an ad hoc basis, by copying existing programs or following simple statistical rules of thumb.

Here we develop a set of analyses to evaluate a portfolio of alternative strategies for sampling biodiversity in order to guide decisions about which methods should be employed and how effort should be allocated across them. We construct efficiency curves for each candidate sampling method, using existing data to predict the biodiversity information expected for a given level of investment. We then combine these individual curves into multidimensional efficiency surfaces describing how any combination of sampling strategies yields information about biodiversity. We demonstrate the method using long-term monitoring data from diverse ecosystems. This method can guide the design of new research projects and can help existing projects determine when new or improved methods should be added to existing sampling portfolios.

**QUANTITATIVE SPATIAL SAMPLING OF BALEEN WHALE PREY IN BRITISH COLUMBIA**  
† Reidy, R.1; Gauthier, S. 2; Cowen, L. 1; Juanes, F. 1

1- University of Victoria 2- Fisheries and Oceans Canada

North Pacific baleen whales have increased in abundance, with humpback whales in British Columbia, Canada increasingly involved in vessel strikes and entanglement in fishing gear. The data required to manage these steadily increasing interactions necessitate a new sampling framework for measuring baleen whale foraging dynamics. While predicting the spatiotemporal overlap between whales and fisheries is needed, limited sampling methods for baleen whale prey has hindered reliable data collection on humpback whales feeding in BC waters. An Acoustic Zooplankton and Fish Profiler (AZFP), designed for long-term monitoring of the water column from...
an upward-looking mooring on the seafloor, offers the ability to collect high resolution prey data as it can be customized to smaller vessels in a downward-looking orientation. Using a vessel-mounted AZFP, I conducted adaptive and systematic surveys off northern and southern Vancouver Island, following a grid of 2-km parallel transects spaced 300 m apart. The surveys were intended to be fine-scale, conducted in daylight hours in regions with and without foraging humpback whales to describe prey in the areas used by the whales. Preliminary results show the whales targeted shallow Pacific herring aggregations off northeast Vancouver Island but deep layers of euphausiids (krill) in southwest Vancouver Island waters. Small-vessel mobility enabled enhanced spatial surveys that were flexible, quantitative, and repeatable, in different habitats within the same feeding ground in southern BC.

**THE LAST MILE CHALLENGE: ECOLABELED SEAFOOD AND FEDERAL LABELING LAWS OUT OF SYNC AT THE END OF THE SUPPLY CHAIN IN LOS ANGELES (YOUTUBE)**

Willette, Demian, A.¹; Esteves, Sofia, C. ²; Fitzpatrick, Ben ³; Smith, Marie, L. ¹; Wilson, Kesterlyn ¹; Yuan, Xiaoya ¹

¹- Biology, Loyola Marymount University ²- Chemistry & Biochemistry, Loyola Marymount University ³- Mathematics, Loyola Marymount University

Seafood ecolabeling programs aim to aid consumers in identifying products with reduced environmental impacts and assure accuracy in labeling and traceability, complementary to or in the absence of governmental regulatory action. The most widely recognized ecolabel seafood certification program is led by the Marine Stewardship Council (MSC). Here explicit testing was conducted on the labeling accuracy of MSC-certified seafood sold in the world’s largest seafood importing market, the United States, per stringent application of federal labeling laws. Commonly sold ecolabeled fresh fish were repeatedly sampled from processors and grocers in Los Angeles, California from 2017-2019 and identified to species using DNA barcoding. Grocers’ mislabeling rates were statistically higher than those of processors. Most mislabeling was attributed to substitution among MSC-certified congeners or labeling with invalid FDA names. Data-driven recommendations include regular DNA-based testing and greater harmonization between certification programs and federal guidelines, particularly in coordination with supply chain end vendors.

Session 7: Behavioural Ecology 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**A MODEL NEUROBIOLOGICAL ORGANISM EXHIBITS ABNORMAL BEHAVIOR IN CO2-ACIDIFIED SEAWATER (YOUTUBE)**

† Ashley Smart ¹; Anne Todgham ²; Eliza Bliss-Moreau ³; Brian Gaylord ⁴

¹- University of California, Davis, Bodega Marine Laboratory ²- Department of Animal Science, University of California, Davis ³- Department of Psychology, California National Primate Research Center, University of California, Davis ⁴- Department of Ecology and Evolution, University of California, Davis, Bodega Marine Laboratory

Emerging research indicates that animal behavior can be altered when animals are exposed to CO2-acidified seawater. Several studies have found changes at the neurological level, linked with abnormal behavior; however, the comprehensive suite of changes in neurophysiology are poorly understood. As a result, there is clear impetus to expand the use of neurological approaches within this line of research. To explore these relationships, I conducted a series of experiments using the marine mollusk, *Aplysia californica*, which has long provided insights into mechanisms underlying
learning, memory, and behavioral patterning. *Aplysia* were exposed to ambient (n=10, pCO₂=530 uatm) and elevated carbon dioxide (n=10, pCO₂=1920 uatm) seawater treatments for 13 days and their behavioral response to cue from an *Aplysia* predator, the anemone *Anthopleura xanthogrammica*, was measured. Experiments included paired trials where each animal was randomly exposed to either an anemone cue or ‘sham’ seawater cue. Total distance traveled in five minutes following cue exposure was measured. *Aplysia* in the elevated pCO₂ treatment experienced elevated movement even without cue exposure compared to individuals in ambient seawater, a result suggestive of a heightened “anxiety-like” state. Thus, *Aplysia* experiences behavioral dysregulation with elevated pCO₂ and has underexploited potential for exploring the neurobiology of behavior in CO₂-acidified seawater.

**SHOULD I STAY OR SHOULD I GO? ADULT DISPERsal OF SEA CUCumBERS IN A PATCH REEF SYSTEM**
† Watkins, H.V.; Côté, I.M.

*Simon Fraser University*

Current recovery strategies for overfished sea cucumber populations generally involve designating no-take zones in fished habitats or restocking fished areas with aquaculture-grown individuals. These strategies aim to (i) improve the probability of successful reproduction through concentrating spawning adults in the protected area and (ii) allow for spillover of adults into adjacent fished habitats. However, little is actually known about sea cucumber dispersal, particularly for adults. To evaluate the potential for these strategies to effectively help with population recovery in overfished areas, we tagged and tracked 70 individual sea cucumbers of two species, *Holothuria mexicana* and *Actinopyga agassizii*, in a shallow patch reef system in Rock Sound, The Bahamas. Over a six-week period, we recorded data on hourly, daily, and weekly movement, as well as association with different types of substrate, such as coral and sand. Despite many individuals moving hundreds of metres over the study period, we observed no movement between our patch sites. Sea cucumbers exhibited a strong association with complex substrate (e.g., corals, sponges, rocks) and significantly higher movement rates in multi-reef patches (i.e., those composed of an array of small dispersed corals, sponges, and rubble rather than a single large reef). This suggests that the availability of suitable habitat may limit adult sea cucumber dispersal. As such, adult spillover may not be an effective means of recolonization in fragmented habitats.

**CONTEXT-DEPENDENT IMPACTS OF ANTHROPOGENIC NOISE ON PLAINFIN MIDSHIPMAN FISH BEHAVIOUR**
† Woods, M.B.¹; Brown, N.A.W. ²; Nikolich, K. ¹; Halliday, W.D. ³; Balshine, S. ⁴; Juanes, F. ¹

1- University of Victoria 2- Department of Fisheries and Oceans Canada 3- University of Victoria, Wildlife Conservation Society Canada 4- McMaster University

Anthropogenic noise has drastically changed natural soundscapes, affecting both terrestrial and aquatic ecosystems and their inhabitants. Noise pollution leads to a myriad of behavioural and physiological consequences for marine life, including fishes. Most studies have focused on the effects of noise on fish in controlled laboratory settings, but these environments often don’t resemble natural habitats, and it is unknown whether the effects seen in aquaria are representative of effects that occur in the wild. We used a combination of laboratory and field experiments to assess the impact of noise on nest defence and parental behaviour of the intertidally-breeding plainfin midshipman fish, *Porichthys notatus*. We observed a significant increase in defensive behaviours shown by males guarding nests without eggs in aquaria during boat noise playbacks compared to ambient conditions (Χ² = 27.17, p < 0.0001). Conversely, we observed no difference
in the defensive or parental behaviours exhibited by males guarding nests with eggs in the field when noise was added to the environment. Our study demonstrates that 1) anthropogenic noise has the potential to impact behaviour in plainfin midshipman fish, 2) context, such as testing environment, presence of eggs, and the type of noise stimulus used, can alter outcomes of such experiments, and 3) more field studies, or lab-field integrative studies, are needed to further investigate the effects of noise and parse apart which experimental components affect certain behavioural outcomes.

THE USE OF LARGE AREA IMAGERY TO DESCRIBE PARROTFISH BITE SCARS AT PALMYRA ATOLL (YOUTUBE)
Charendoff, J.A. 1*; Edwards, C.B. 1; Pedersen, N.E. 1; Petrovic, V 2; Sandin, S.A. 1; Smith, J.E. 1

1- Scripps Institution of Oceanography 2- UCSD, CalIT2

Parrotfish are a group of herbivorous fishes thought to have an important top-down effect on reef ecosystems due to their ubiquity in herbivore assemblages and unique feeding behavior. Parrotfish belonging to the scraper and excavator feeding groups leave scars on reef structures that are generally thought to create valuable open space for recruitment and growth of benthic organisms. Here, we assess spatial patterning and feeding selectivity of parrotfish bite scars made across the reefs of Palmyra Atoll (USA; central Pacific). To do so, we used a large-area imaging technique through which 3D models were created using Structure from Motion to virtually archive reef community structure, and outlined all visible parrotfish bite scars. Across 4 200m2 reef plots, over 2000 parrotfish bite scars were identified and mapped onto the benthic landscape so that the surrounding benthic cover could be identified to the nearest functional group. Variance-to-mean ratios (VMR) show high spatial clustering at all sites, however differences were present. Feeding selectivity of parrotfish bite scars showed highest preference for turf and encrusting macroalgae. Variability in VMR and selectivity between sites may reflect natural variability in parrotfish community structure across the fore reef at Palmyra. Understanding the spatial distribution and selectivity of parrotfish feeding activity may provide insight into specific locations in the reef that experience short-term, but high-frequency disturbance events and represent areas of benthic succession that differ from other areas in the reef.

ASSESSING VARIATION IN THE DIETARY NICHE OF THE CALIFORNIA SPINY LOBSTER PANULIRUS INTERRUPPTUS (YOUTUBE)
† Pollard, E.A. 1*; Hovel, K.A. 1; Dunn, R.P. 2

1- San Diego State University 2- Baruch Marine Field Laboratory, University of South Carolina

The California spiny lobster, Panulirus interruptus, is an economically and ecologically important species inhabiting rocky reef and kelp forest communities within the Southern California Bight. As an abundant large-bodied predator, California spiny lobsters may exert top-down control of herbivorous sea urchins, thereby promoting the persistence of habitat-forming algae and consequently community stability. Despite their prominent role in community dynamics, their potentially large influence on prey species, expansive range, and value as a fishery species, relatively little is known of the exact diet composition of California spiny lobsters and how this may shape their dietary niche. To investigate potential niche breadth changes in a prominent predator species, we quantified the dietary niche of the California spiny lobster using stable isotope values ($\delta^{13}C$ and $\delta^{15}N$) from tissues of lobsters, potential prey species, and primary producers (macroalgae). Our results reveal some dietary niche overlap, but also some potential expansion of dietary niche between size classes, revealing that larger lobsters may be broadening their diet to include a larger array of species.
MOVEMENT AND EROSIONAL EFFECTS OF A HIGHLY ABUNDANT REEF CONSUMER ARE MEDIATED BY A NEWLY DOMINANT SPACE-HOLDER
† Saldaña, P.H. 1*; Goetz, N.A. 2; Altieri, A.H. 1

1- Department of Environmental Engineering Sciences, University of Florida, Gainesville USA 2- Department of Biology, San Diego State University, San Diego USA

Caribbean coral reefs have undergone drastic changes in composition and live coral cover due to various anthropogenic stressors. These changes have accompanied an increasingly high cover of algae and other sessile invertebrates such as zoanthids, sponges and gorgonians. Although these organisms may directly compete with stony corals for space, we hypothesize that they may also have positive indirect effects on the reef framework by mediating the impacts of bioeroding consumers. Our recent work on the Caribbean coast of Panama has revealed that the reef urchin, *Echinometra viridis*, is a bioeroder that reaches exceptionally high densities in shallow reefs with proportional consumptive effects. In the present study, we investigate how the consumptive effects of *E. viridis* on corals are influenced by a newly dominant space-holder, the mat zoanthid, *Zoanthus pulchellus*. Our lab and field experiments suggest that 1) *E. viridis* decreases the skeletal density of dead corals by directly consuming calcium carbonate 2) *E. viridis* prefer to inhabit and graze on dead corals that are not covered by *Z. pulchellus*, and 3) dead coral fragments covered by *Z. pulchellus* are less vulnerable to urchin-induced bioerosion than algae-covered fragments. We conclude that newly dominant space-holders such as zoanthids may mitigate the bioerosion of shallow reefs under increased pressure from consumers such as *E. viridis*.

HOST WITH THE MOST: RHIZOCEPHALAN PARASITISM AND EPIBIOSIS IN DOCK SHRIMP (YOUTUBE)
† Yoshioka, R.M. 1*; Brown, S. 2; Schram, J.B. 1; Galloway, A.W.E. 1

1- Oregon Institute of Marine Biology, University of Oregon 2- Whitman College

Rhizocephalan barnacles are parasitic castrators, notorious for their effects on their crustacean hosts. The rhizocephalan *Sylon* sp. infects numerous species of shrimp and is recorded to reach prevalences of over 30%, but there is relatively little known about its effects on hosts and cascading influence on other ecosystem members. Prompted by a casual natural history observation of a red alga growing on a *Sylon*-infected shrimp, we surveyed dock shrimp *Pandalus danae* at Friday Harbor Laboratories, Washington. Surveyed shrimp had a *Sylon* prevalence of 43%, suggesting a considerable regulation of host population through parasitic castration. Shrimp infected with *Sylon* had higher rates of epibiotic fouling relative to uninfected shrimp, and epibiosis increased with *Sylon* developmental stage. The ciliate *Ephelota* and red algae were the most common epibionts, but we also observed bryozoans, hydroids, and thoracican barnacles on dock shrimp. Further investigations are needed to determine the mechanistic connection between *Sylon* parasitism and epibiosis (e.g. molting or behavior effects) and whether epibiosis affects shrimps’ interactions with other species (e.g. predation by fish). Nonetheless, our results thus far point to a potentially substantial but unappreciated parasite’s effect on its host.

BEHAVIORAL VARIABILITY OF CRAWL-AWAY LARVAE MODIFIES DISPERSAL POTENTIAL IN A MARINE GASTROPOD (YOUTUBE)
† Hooks, A.P. *; Burgess, S.C.

Florida State University

Many invertebrates encapsulate embryos on the benthos, but species differ in whether juveniles emerge and crawl away, or larvae emerge and swim away. The distinction is important because
juveniles that crawl-away exhibit less dispersal potential than larvae that swim away. We report here on a recent finding where larvae of the Florida crown conch *Melongena corona* fit neither of these distinctions. Hatchlings emerged as crawl-away larvae (pediveligers), but some fraction of larvae exhibited brief periods of swimming before crawling again. The larval velum is tucked under the shell when crawling. We assessed metamorphic competency and found that 44% of hatchlings were competent to metamorphose at emergence but did not. Metamorphic competency increased within a few days of hatching, but many larvae delayed metamorphosis for days to weeks in the lab and the field. In the lab, we manipulated environmental cues to test if we could induce or suppress swimming behavior. More hatchlings swam in the absence of cues related to putative larval food or habitat, and hatchlings only grew in the presence of live sediment, representing a juvenile food source. Hatching from benthic egg capsules as crawl-away larvae, while also maintaining the capacity to swim, may have evolved to maintain flexibility in balancing the benefits and risks of benthic versus pelagic mortality, and to maximize survival by dispersing from reproductive locations and nursery habitat.

Session 8: Fisheries Ecology 1

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

**DOES BAIT TYPE AFFECT THE RATES OF BYCATCH IN THE PUGET SOUND LINGCOD FISHERY?**

(YOUTUBE)

Andrews, K.S. *; Tonnes, D.M.; Gaydos, J.K.

1- NOAA Northwest Fisheries Science Center 2- NOAA Fisheries West Coast Regional Office 3- The SeaDoc Society

In 2010, yelloweye Sebastes ruberrimus and canary rockfish S. pinniger were listed as ‘threatened’ and bocaccio S. paucispinis as ‘endangered’ in Puget Sound, WA under the Endangered Species Act (ESA) based on large decreases in abundance over the last 50 years and the determination that each species met the criteria to be considered a distinct population segment (DPS) as defined under the ESA. In order to reduce mortality and bycatch of these ESA-listed species, which primarily occupy habitats deeper than 120 feet, the Washington Department of Fish & Wildlife (WDFW) implemented new regulations that prohibited fishing for, retaining or possessing any rockfish species and prohibited all ‘bottomfish’ fishing deeper than 120 feet within DPS waters. In this study, we tested whether catch-per-unit-effort (cpue) of rockfish bycatch and targeted lingcod Ophiodon elongatus catch varied with commonly used bait types (live, frozen and artificial). We chartered local recreational fishing charter captains and targeted lingcod across 12 sites in two regions of the DPS (n=37 days). We used one of the three bait types at one of three sites each day, varying the bait type across sites on subsequent days. We found that rates of targeted lingcod catch were similar for each bait type, while using large, live bait types resulted in lower rockfish bycatch. Understanding the magnitude and methods available to reduce bycatch in fisheries is an important step in making decisions concerning the tradeoffs between conservation efforts of threatened species and impacts on fishing communities.

**BOLSTERING OYSTER RESILIENCE FOR AQUACULTURE AND REEF RESTORATION USING PREDATOR CUES**

(YOUTUBE)

Belgrad, B.A.; Combs, E.M.; Walton, W.C.; Smee, D.L.

1- Dauphin Island Sea Lab 2- Florida Atlantic University 3- Auburn University

Many mollusks alter their shell morphology in response to predator exudates or injured conspecifics to lower their predation risk. However, studies have yet to examine whether this
predator-avoidance response can be applied under aquaculture scenarios to improve fisheries. We tested whether exposure to predator cues under hatchery conditions can increase the survival of oysters, Crassostrea virginica, planted in the wild. Juvenile oysters grown in a flow-through system were exposed to either caged blue crabs, Callinectes sapidus, or controls of empty cages for four and eight weeks then placed in the field for 30 days. We compared the shell crushing force, shell morphological characteristics, and individual survival of oysters across predator exposure time and treatments. Oysters grown in the hatchery for eight weeks were, on average, 46% larger and almost 2x stronger than oysters grown for four weeks. However, predator exposure also caused a 50% increase in shell strength for both time periods. These differences yielded significantly greater gains in survivorship over time as predator induced oysters nursed for four weeks exhibiting 53% higher survival in the field than unexposed oysters while this survivorship gain jumped to 300% for eight weeks of cue exposure. Our findings demonstrate that predator cues can be an effective means for the industry to increase the survival rate of aquaculture and restoration efforts, and may potentially be applied to other bivalve fisheries (e.g. clams, mussels).

IGF1 AS A HORMONE BIOMARKER OF GROWTH RATE IN PACIFIC ROCKFISHES (YOUTUBE)
Bersin, T.B.1*; Cordova, K.L. 1; Journey, M.L. 2; Beckman, B.R. 2; Lema, S.C. 1

1- Cal Poly, San Luis Obispo 2- NOAA Fisheries

Determination of fish growth and age is fundamental to effective management of marine fishes. Current direct-estimation methods for measuring growth such as capture-mark-recapture can be limited by the ability to obtain sufficient recaptures for growth estimates and may only provide growth rate estimates extrapolated from longer time periods. Concentrations of the hormone insulin-like growth factor-1 (IGF1) in blood circulation correlate strongly with recent growth rate and feeding variation in several species of marine groundfish, thereby providing an alternative method for quantifying growth rate quickly in large numbers of fish. Growth hormone (GH) regulates growth in fish by stimulating liver synthesis of IGF1, which then activates growth-promoting pathways. Under nutritional stress, fish with low IGF1 levels and slow growth can still exhibit elevated blood GH, suggesting that food limitation may alter liver sensitivity to GH stimulation. However, the mechanism(s) of this inhibition remain relatively unknown. We examined the effects of fasting on GH induction of IGF1 in Gopher Rockfish, Sebastes carnatus. Fish were either fed at a rate of 9% per g body mass or fasted for 14 d and then injected with recombinant GH or saline (control). GH injection increased liver igf1 mRNAs in fed but not fasted rockfish. Fasted fish exhibited reduced mRNA transcript and phosphorylation levels of cellular components key to IGF1 production. Overall, these findings support liver GH resistance as a mechanism of lower IGF1 production and reduced growth of fish under nutritional stress.

UTILIZING A BLOOD-BASED BIOMARKER TO EXPLORE SPATIAL AND TEMPORAL TRENDS IN GROWTH RATES OF BLUE ROCKFISH (SEBASTES MYSTINUS) (YOUTUBE)
† Brauer, E.1*; Bersin, T. 1; Hack, N. 2; Journey, M. 3; Waltz, G. 1; Beckman, B. 3; Lema, S. 1

1- California Polytechnic State University, San Luis Obispo 2- University of California, Santa Cruz 3- NOAA Fisheries

While evaluations of fish populations have historically relied on surveys of fish abundance, quantitative measures of growth rate could provide additional information crucial for effective fisheries management. In fish, somatic growth relates directly to individual fitness, as larger fish typically have higher fecundity and survivorship. Average growth rates in wild populations change both spatially and temporally in patterns associated with environmental heterogeneity, and quantitative evaluations of growth rate could help identify and predict fine-scale variation in
population productivity. Recently, the hormone insulin-like growth factor-1 (IGF1) was established as a reliable blood-based physiological biomarker for growth rate in several fishes including Pacific rockfishes (genus *Sebastes*). From 2016 through 2018, we measured IGF1 levels from Blue Rockfish (*Sebastes mystinus*) at two different sites on the central coast of California, both inside and outside of a Marine Protected Area (MPA) at each site. We observed higher IGF1 concentrations at one site than the other across all three years. We also found that the effect of protection status on IGF1 levels varied between sites and over time indicating that MPAs may have an inconsistent effect on Blue Rockfish growth. This novel approach has the potential to provide robust growth rate information that could aid in the identification of critical habitat and inform marine resource managers about the spatial and temporal trends in marine fish growth for culturally and economically important species.

**UNHEALTHY LIVE BAITS POSE PROBLEMS FOR FLORIDA SPINY LOBSTER, *PANULIRUS ARGUS* HARVEST BY THE COMMERCIAL TRAP FISHERY**

Butler, C.B. 1*; Butler, J. 2; Ross, E.P. 2; Matthews, T.R. 2

1- Florida Fish and Wildlife Conservation Commission/Florida International University 2- Florida Fish and Wildlife Conservation Commission

The spiny lobster trap fishery in Florida uses live, sublegal-sized lobsters to lure other lobsters into traps. Long term confinement of lobsters results in the degradation of their nutritional condition (i.e., decreased blood serum protein levels and severely atrophied hepatopancreas) or death. Though recent research has identified that bait lobsters with reduced nutritional condition are less attractive to other lobsters – which results in reduced trap catch rates – no one has identified how the nutritional condition of lobsters varies throughout the year, and how that might affect commercial landings during the fishing season. We monitored the health of sublegal- and legal-sized lobsters caught in traps, wild lobsters hand-caught in the fishing area, and wild lobsters hand-caught inside Everglades National Park (ENP), a shallow-water lobster nursery area where lobster fishing is prohibited. We compared the health of lobsters from these three areas monthly, via two nutritional indices – hepatopancreas dry weight and blood serum protein. We observed low values of these indices in both sublegal- and legal-sized lobsters from traps, indicating that those lobsters are nutritionally compromised. Wild hand-caught lobsters from locations within the trap area did not exhibit reduced index values. Fishery management practices that adequately address lobster health will likely reduce sublegal-lobster fishery mortality and increase catch per trap and landings, resulting in increased fishery sustainability.

**FISH AS MOBILE MONITORS OF HYPOXIC CONDITIONS**

† Cavole, L. M. 1*; Limburg, K. 2; Gallo, N. 1; Salvanes, A.G.V 3; Ramírez-Valdez, A. 1; Levin, L. 1; Aburto-Oropeza, O. 1; Hertwig, A. 4; Liu, M.-C. 4; McKeegan, K.D. 4

1- Scripps Institution of Oceanography 2- SUNY College of Environmental Science and Forestry 3- University of Bergen 4- UCLA

The ocean is rapidly losing oxygen, with profound implications for marine organisms. Within Eastern Boundary Upwelling Systems, such as the California and the Benguela Current Ecosystems, it is largely unknown how the ongoing expansion, intensification and shoaling of Oxygen Minimum Zones (OMZs) will affect fish and fish populations. One of the first steps to filling this knowledge gap is through the development of techniques to track fishes’ exposure to hypoxic waters (< 22 µmol kg⁻¹) when inhabiting OMZs. Here, we explore the elemental and isotopic composition of fish otoliths from distinct OMZs, the Southern California Bight, in the Pacific Ocean, and the Namibian shelf, in the Atlantic Ocean, in an attempt to detect patterns of chemical variation in otoliths.
associated with hypoxia. We observed that deep-water fishes spanning a range of life history traits (e.g. longevity, size at maturity, maximum size and age, growth rate, parental investment and thermal history) exhibited a common elemental fingerprint when compared to a shallow-water marine fish from better oxygenated waters. In addition, we observed that boron ratios in otoliths seem to work as a tracer of pH in more acidic waters found in OMZs. We hypothesize that the underlying mechanism for the common elemental fingerprinting of fish otoliths inside OMZs can be attributed to the unique biogeochemistry found on the margins of these highly productive upwelling systems as well as the physiological constraints resident organisms are perennially exposed to, including reduced oxygen and pH conditions.

**ECOLOGICAL CONSEQUENCES OF CLIMATE-INDUCED CHANGES IN SPATIAL OVERLAP BETWEEN EASTERN BERING SEA POLLOCK AND THEIR PREDATORS**

Maurice Goodman¹; Gemma Carroll ²; Stephanie Brodie ³; Arnaud Grüss ⁴; James Thorson ⁵; Elliott Hazen ⁶; Giulio De Leo ¹

1- Stanford University 2- University of Washington & NOAA Alaska Fisheries Science Center 3- NOAA Southwest Fisheries Science Center 4- National Institute of Water and Atmospheric Research, New Zealand 5- NOAA Alaska Fisheries Science Center

An abundance of studies in marine systems document species ranges shifts in response to climate change, and many more have used species distribution models to make future projections of species ranges. However, there is increasing interest in moving beyond single-species projections to understand changes in species interactions and community composition. We use spatiotemporal models to characterize (1) the biomass distribution of juvenile walleye pollock and their predators, and (2) pollock consumption by predators. In doing so, we assess how changes in spatial overlap between pollock and their predators relate to changes in predation integrated across the Eastern Bering Sea, and we evaluate the utility of range overlap metrics for understanding the ecological consequences of coupled species range shifts. We find marked shifts in both spatial overlap between juvenile pollock and their predators (particularly Arrowtooth Flounder) and in predation on pollock, but show that spatial overlap between juvenile pollock and their predators is a poor proxy for predation on pollock.

Session 9: Intertidal Ecology 1

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

**AI SURVEILLANCE REVEALS EELGRASS WASTING DISEASE IS LINKED TO TEMPERATURE ANOMALIES ACROSS LATITUDINAL SCALE**

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1- Cornell University 2- University of California-Davis 3- Smithsonian Environmental Research Center 4- University of Alaska-Fairbanks 5- University of Central Florida 6- Hakai Institute 7- San Diego State University 8- Oregon State University

Warming oceans due to climate change endanger the health of coastal ecosystems through direct impacts from temperature stress and increased risk of infectious disease outbreaks. Eelgrass meadows from San Diego to Alaska are highly productive and biodiverse ecosystems that are vulnerable to temperature stress, disease, and interactions between these stressors. To facilitate geographic-scale disease surveillance, we developed and trained EeLISA, the Eelgrass Lesion Image Segmentation Analyzer, an artificial intelligence program that quantifies eelgrass wasting disease 10,000x faster and with equivalent accuracy to a human processor. We used EeLISA to process
disease signs on >3700 individual eelgrass shoots, during surveys of meadow health in 32 meadows across 23° of latitude along the west coast of North America. The prevalence of eelgrass wasting disease infections ranged from 10 to 90%, with some locations showing outbreak conditions and severe disease damage. We compared disease levels with temperature metrics from both remote sensing and in situ temperature records; locations experiencing warm temperature anomalies in summer and faster rates of spring warming in 2019 had greater incidence and severity of disease. Climate-driven warming is likely to facilitate eelgrass wasting disease outbreaks, potentially triggering ecological collapse in these essential coastal ecosystems.

**TINY BUT MIGHTY: TROPHIC REDUNDANCY AND COMMUNITY RESILIENCE IN INTERTIDAL COMMUNITIES FOLLOWING A DISEASE OUTBREAK**

† Bachhuber, S.M.; Menge, B. A.

*Oregon State University*

In 2013-14, loss of the keystone predator *Pisaster ochraceus* due to Sea Star Wasting in rocky intertidal habitats created a natural removal experiment that prompted extensive investigation into ecological resilience mechanisms along the North American west coast. One source of resilience to *Pisaster* loss is predatory compensation by other small intertidal predators, including whelks and other sea stars. We ask whether persisting small predators can compensate for keystone predator loss by consuming mussels and barnacles at the lower edge of the mussel bed, and whether this signal is spatially variable. We conducted a cage exclusion experiment with four predator treatments: no predators, the whelk *Nucella ostrina*, the sea star *Leptasterias spp.*, and both predators (all at site-specific natural densities) at 6 sites spanning 3 Oregon coastal capes. We used photo analysis to quantify abundance of prey species at the end of the 18-month experiment. Preliminary results indicate that compensatory predator effects are most significant at sites with enough prey recruitment to support rapid predator growth, but that predators are overwhelmed at high recruitment sites and thus are unable to suppress mussel bed growth, with corresponding consequences for treatment plot diversity. Understanding fine scale variation in these resilience mechanisms, and the relative importance of top-down vs. bottom-up control, is particularly important in the face of catastrophic events (e.g. disease outbreak, marine heat waves) which are increasing in frequency and severity with climate change.

**DEVELOPING IN THE INTERTIDAL: EFFECTS OF SALINITY AND TEMPERATURE ON DEVELOPMENT TO THE PENTAMERAL JUVENILE SEASTAR, P. EXIGUA**

Regina Balogh†; Maria Byrne

*The University of Sydney*

For intertidal marine species, salinity and temperature are important environmental factors with conditions ranging from oceanic salinity and temperature at high tide to almost freshwater conditions due to rain accompanied by aerial temperature exposure at low tide. The interactive effects of these stressors across development to the juvenile is not known. We investigated the impacts of salinity (29-41 ppt) and temperature (20-24 °C) on holobenthic intertidal development to the 5-armed juvenile asterinid seastar Parvulastra exigua. There was an interaction between the stressors with highest mortality in the high salinity and temperature (38 ppt, 41 ppt, 24 °C) treatments. Developmental stage progression was enhanced by increased temperature. On day 1, there was an interaction between salinity and temperature on developmental stage progression, where high salinity (41 ppt) retarded development at the control temperature (20 °C). The juveniles reared at 24 °C were smaller than those at cooler temperatures, suggesting application of the temperature size rule. The low (29 ppt) and high (38 ppt, 41 ppt) salinity treatments produced
the smallest and largest juveniles, respectively. Body plan development was perturbed with deviations from pentamery at 29 ppt, 32 ppt and 41 ppt and at 22 °C and 24 °C in formation of no armed juveniles and ones with abnormal arm number (4,6,7 arms). Normal development at 35-38 ppt and 20-22 °C reflects breeding period conditions. Prolonged exposure to low and high salinity and increased temperature is deleterious to development in P. exigua and alters body

FIRE NEMATOCYSTS FIRST AND ASK QUESTIONS LATER: SEA ANEMONES CHOOSE PREY AFTER INGESTION (YOUTUBE)
† Bedgood, S.A.*; Bracken, M.E.S.

University of California, Irvine

Sea anemones in the genus Anthopleura are ubiquitous on rocky shorelines along the west coast of North America, but we still know little about their many ecological interactions. They serve as primary producers (via algal symbionts), scavengers, predators, and facilitators of biodiversity. Here we focus on the diet of sea anemones and describe a collection of natural history observations and experiments aimed at understanding their complex trophic interactions. These include video of predation events during high tides, the identity of prey across sites and seasons, and a controlled feeding choice experiment. We hypothesized that sea anemones would consume any animal that comes in contact with their tentacles and reject algae and inorganic matter. Our results show some animals (a few terrestrial) must avoid these opportunistic predators, but others are actively rejected, even after ingestion! The most notable rejected animal was a common intertidal snail, Tegula funebralis, which often takes shelter under sea anemones. Algae and inorganic material are ingested but quickly rejected suggesting that anemones fire nematocysts first and question dietary choices later.

Interior marsh loss driven by physical factors (YOUTUBE)
† Beheshti, K.M.*; Pavlak, A. ; Wasson, K.  

1- University of California, Santa Cruz 2- University of California, Santa Cruz and Elkhorn Slough National Estuarine Research Reserve

Understanding the relative importance of biotic versus abiotic factors in structuring landscapes is critical for the management and conservation of coastal habitats. Most investigations of salt marsh dynamics have been conducted on the US East Coast with a focus on how bottom-up processes influence these grass-dominated marshes. We conducted a two-year (2016-2018) field experiment in the woody perennial marshes of the US West Coast (Elkhorn Slough) where we tested the relative importance of a common crab and ecosystem engineer, Pachygrapsus crassipes, and/or elevation in facilitating or impeding interior marsh dieback. Our results show that in the marsh interior, crabs have little to no effect on marsh dieback and the variation in marsh colonization that we were able to track was mainly due to physical factors, including elevation and size of dieback area. Previous work at the marsh-bank edge showed that crabs play a strong role in depressing marsh biomass via consumptive and engineering effects. This study adds to the existing literature demonstrating how spatially explicit the relative importance of biotic versus abiotic factors are in structuring landscapes.

LESS THAN THE SUM OF ITS PARTS: BLADE CLUSTERING REDUCES DRAG IN THE BULL KELP NEREOCYSTIS LUETKEANA (YOUTUBE)
† Breitkreutz, Alana K.*; Coleman, Liam J.; Martone, Patrick T.

The University of British Columbia
Flow-induced drag is an important determinant of kelp morphology. Kelps have various strategies to minimize drag and avoid dislodgment, many of which have been well documented and studied. In this study, we consider how the multi-bladed morphology of the bull kelp, *Nereocystis luetkeana*, might reduce drag through the interactions between its many blades. To understand this, we measured drag on individual blades and developed a model to estimate how much drag a bull kelp might experience if interactions between its many blades afforded it no drag-reducing benefit. We compared these estimations to measurements of drag on intact kelps, and continued measuring drag as we removed blades one by one in order to understand how drag depends on blade number. We found that intact bull kelp experience less than half of the drag that their blades would experience in isolation, and that this benefit is actually more pronounced at higher blade numbers. This may be why this species tends to have more blades when found in habitats with more intense flow. Overall, this species’ multi-bladed morphology is likely part of what allows it to grow in hydrodynamically stressful environments.

**AGE AND GROWTH OF THE PISMO CLAM (*TIVELA STULTORUM*) IN CALIFORNIA (YOUTUBE)**
† Clark, N.*; Marquardt, A.; Maietta, E.; Ruttenberg, B.

*California Polytechnic State University, San Luis Obispo*

Pismo clams *Tivela stultorum* are an iconic bivalve species in California which once supported a thriving commercial and recreational fishery. Overharvest led to the closure of the commercial fishery in 1947, but a recreational fishery remains technically open. Despite decreased fishing pressure, Pismo clam populations have continued to decline, and management has relied on biological information that has not been updated in many decades. Our study aims to elucidate the relationship between age and size, a key life history parameter for effective management and recovery of fisheries. We collected clams from the California Central Coast at Pismo Beach, CA and sites throughout Southern California during 2018-2019. We sectioned valves of shells, determined age by counting annual growth rings, and fit a von Bertalanffy growth function. Historical records indicate that clams reach legal harvestable size (4.5in/114mm) in 6-9 years. However, our findings indicate that across the state it takes an average of 9-13 years to reach harvestable size today. This information has implications for if and how this species will recover and can be utilized to help improve management of the fishery.

**Partner preference in the intertidal: possible benefits of ocean acidification to sea anemone-algal symbiosis**
† Coleman, N.B.*; Bingham, B.L. 2

1- Western Washington University 2- Western Washington University, Shannon Point Science Center

Ocean acidification (OA) threatens many marine species and areas of the Salish Sea that experience upwelling are particularly susceptible to low pH. While OA literature often describes negative impacts to calcifying organisms and economically important shellfish, not all species appear to be as threatened, particularly photosynthesizers. *Anthopleura elegantissima*, an intertidal anemone, hosts two photosynthetic symbionts: *Symbiodinium muscatinei* and *Elliptochloris marina*. The holobiont consists of a cnidarian host and photosymbiont that could be affected differently by changing CO2. To determine effects of OA on this relationship, *A. elegantissima* hosting each symbiont individually, both simultaneously, or none were subjected to one pCO2 level (800ppm, 1200ppm, or 1800ppm) for 10 weeks. Every 3 weeks we measured: gross photosynthesis, symbiont density, respiration rate, ROS, and CZAR. Over this period symbiont photosynthesis did not change in pCO2 (800ppm) but decreased at high pCO2 (1800 ppm). At intermediate pCO2 (1200 ppm), photosynthesis decreased in *E. marina* but increased in *S. muscatinei*. Respiration rate and CZAR both increased with
decreasing pH but respiration was higher in hosts of E. marina and hosts lacking symbionts. ROS increased with decreasing pH and was greatest in S. muscatinei anemones. Anemones starting with 50% of each symbiont shifted toward a higher proportion of S. muscatinei with decreased pH. This suggests S. muscatinei may benefit from elevated pCO₂ and A. elegantissima hosting them could gain competitive advantage under OA.

Session 10: Population Biology and Ecology 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

IMPACT OF COASTAL URBAN STRESSORS ON MARINE INVERTEBRATE ADAPTATION AND DEVELOPMENT (YOUTUBE)
† Armstrong, M.A.*; Bay, R.A.

University of California, Davis

Urban environments provide a unique opportunity to observe rapid evolution in response to novel selective pressures. Urbanization is rapidly changing ecosystems, fragmenting habitats, increasing pollution levels and raising temperatures relative to the surrounding areas. Patterns of phenotypic, physiological and genomic variation in terrestrial organisms show that species can adapt to urban stress, but we know very little about urban evolution in marine organisms. Marine species often have larger ranges and higher gene flow than terrestrial systems, partially due to the presence of long planktonic larval stages, and these differences could mean that mechanisms of adaptation and resilience are not the same in both systems. In particular, the marine intertidal zone faces a complex mixture of stressors, including exposure, to runoff, wastewater, and coastline hardening, due to its proximity or coastal urban cities. Coastal urban pollution has been shown to lower population connectivity as wastewater and stormwater outflow act as physical barriers to larval dispersal. Further, exposure to contaminants associated with urban environments can lead to lower genetic diversity and developmental abnormalities. I am using the Pacific purple sea urchin (Strongylocentrotus purpuratus) as a model to address these questions due to its widespread range in both urban and non-urban areas, and its value as a developmental model. I will use a combination of population genomics and developmental biology to investigate the potential for S. purpuratus populations to adapt to urban pollutants.

ESTIMATING GROWTH, SIZE-DEPENDENT MORTALITY AND TAG-LOSS IN A MARK-RECAPTURE STUDY: DEMOGRAPHY OF WAVY TURBAN SNAILS IN SOUTHERN C (YOUTUBE)
McCann, B.M.*; Johnson, D.W.

Department of Biological Sciences, California State University, Long Beach

Tagging studies are often used to measure survival and growth in wild populations. However, issues such as low returns of tagged animals, tag loss, and handling mortality can affect the precision and accuracy of demographic estimates. We conducted a mark-recapture study to measure the survival and growth of juvenile and adult wavy turban snails (Megastraea undosa). Our study highlights several methodological advances including improved methods for estimating rate of tag loss, and a way to estimate handling mortality by comparing encounter histories of animals immediately after tagging and after several weeks in the field. Tag loss was moderate (≈ 15% over a 100-d period) and handling mortality was substantial during the fall (≈ 55%), but negligible during the spring. If we did not account for tag loss and handling mortality our estimate of survival would have been severely underestimated (≈ 46% lower over a 100-d period). After accounting for such effects, our study revealed that survival probably increased sharply with body size, but survival did not differ among seasons. These snails are slow growing, mature after approximately six years, and can
routinely grow to > 10 years old. There is an emerging fishery for this species and because our results suggest the oldest snails have a very high reproductive value, measures that protect these large individuals are likely to be highly beneficial for the resilience of these populations.

**GENETIC AND EPIGENETIC PATTERNS IN POCILLOPORA SPP. IN MO’OREA, FRENCH POLYNESIA REVEAL RECRUITMENT OF MULTIPLE SPECIES.**

Modak T.H.;* Wong K.H.; Schedl M.; Puritz J.B; Putnam H.M

*University of Rhode Island*

Coral reefs are increasingly degraded due to a variety of disturbances. There is an urgent need to study resilience of coral species and to understand how reefs are maintained through connectivity and recruitment. Following catastrophic coral mortality on reefs in Mo’orea, French Polynesia, through predation by Acanthaster planci and cyclone, Pocillopora spp. recovered rapidly and are a dominant species in a variety of habitats. The goal of our study was to understand genetic and epigenetic patterns across habitats with varied environmental factors. We collected Pocillopora spp. at 4 sites on the north shore of Mo’orea and employed an epiRAD approach which combines double digest restriction site-associated sequencing (ddRAD) with a methylation sensitive restriction enzyme to assess genome-wide patterns of methylation. Our multi-pass analysis identified that samples do not separate genetically by sampling site, but include multiple putative species that show strong concordance with results from mtORF sequencing. Within each of the two main putative species with greatest comparative sample sizes to test for site effects, FST and PST (methylation FST analog) within putative species clusters are low, but Pst shows species specific variability. Outlier analysis within each putative species cluster identified outlier loci under selection. Our results suggest that Pocillopora spp. are diverse and cryptic in Mo’orea and provide both genetic and epigenetic descriptions for use in further functional analyses.

**PASSIVE ACOUSTIC MONITORING REVEALS YEAR-ROUND SPATIOTEMPORAL DISTRIBUTION PATTERNS OF SOUTHERN ALASKA RESIDENT KILLER WHALES**

† Myers, H.J.1*; Olsen, D.W. 2; Matkin, C.O. 2; Konar, B.H. 1

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

Resident killer whales (*Orcinus orca*) are a genetically and acoustically distinct piscivorous ecotype and are top predators in the North Pacific Ocean. Understanding their spatiotemporal distribution and habitat use patterns is therefore important both for management of this federally protected species and to provide insight into trends and changes within the marine ecosystem. The southern Alaska resident killer whales are the largest documented population of resident killer whales in the eastern North Pacific, with an estimated 700 animals and 33 identified pods. Beginning in fall 2016, autonomous recording hydrophones were placed in three strategic locations in the northern Gulf of Alaska. Killer whale vocalizations were identified in this acoustic dataset to provide the first year-round description of resident killer whale spatiotemporal distribution in this area. Vocalizations were recorded on the most days throughout the year in Montague Strait, whereas Hinchinbrook Entrance and Resurrection Bay showed highly seasonal patterns of presence, with peaks from March to July and May to June, respectively. One year of acoustic data was further analyzed to assess the number of hours per day that resident killer whales were recorded. The number of hours per day at each location further underscored the pattern in daily detections. This research provides new insight into wintertime spatiotemporal distribution and expands on existing long-term studies of the southern Alaska resident killer whales.
ADAPTATION OF THE BRYOZOAN BUGULA NERITINA TO HUMAN INDUCED ECOLOGICAL CHANGE THROUGH TRANSGENERATIONAL PLASTICITY (YOUTUBE)† Neylan, I. P.*; Sih, A.; Stachowicz, J. J.

University of California, Davis

Transgenerational plasticity (TGP) occurs when a change in offspring phenotype is cued by an environmental signal in the parent (or previous generations) without involving a genetic change and may be an important mechanism allowing organisms to adapt more rapidly and directly in response to their environment. However, despite increasing numbers of empirical examples of TGP, there are few tests of the conditions that promote its evolution and maintenance. Using a common fouling invertebrate, Bugula neritina, I compared patterns of TGP in response to copper stress across two populations with differing historical levels of copper pollution (one with high historical copper levels and one with low levels). Using a split brood design, I exposed mothers from both populations to copper or control treatments in the lab and then had them brood naïve larvae in the field before exposing half of each brood to copper or control and then allowing them to grow in the field for six weeks. Maternal copper exposure had a strong negative effect on offspring growth and survival in the population with low levels of copper pollution and little to no effect in the population with high copper levels. This population-level difference may be explained by differences in maternal provisioning as mothers from the high copper population were able to create larger larvae in response to copper exposure. These results indicate that maternal effects may manifest at different life-stages in offspring and that TGP may be a locally adapted trait selected for or against based on past patterns of exposure.

Origami for community regime shift (YOUTUBE)
Tekwa, E.W.*; McManus, L.C. 2; Greiner, A. 3; Colton, M.A. 4; Webster, M.S. 5; Pinsky, M.L. 1

1- Rutgers University 2- Rutgers University / University of Hawaii 3- University of Toronto 4- Coral Reef Alliance 5- New York University

We present instructions on how to construct a phase transition diagram of a theoretical two-species community using origami paper, and illustrate a regime shifting force using a pen going through the origami structure. This novel geometric method is based on simple stability criteria and allows us to visualize transitions between regimes such as coexistence, single-species dominance, and alternative stable states across different biotic and environmental conditions. We show how the method can be used to resolve coral-macroalgal dynamics under multiple stressors and interventions. The paper Geometric Analysis of Regime Shifts in Coral Reef Communities is forthcoming in Ecosphere, and an early draft is available at: https://doi.org/10.1101/2020.01.10.899179.

RAPID MORPHOLOGICAL AND REPRODUCTIVE RESPONSES OF WILD TEGULA POPULATIONS TO DISEASE-DRIVEN REMOVAL OF SEA STAR PREDATORS† Wetmore, L.W.*; Anderson, T.W.

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

The potential for aquatic gastropods to display phenotypic plasticity in response to predator cues is well documented experimentally. In California, it has been hypothesized that observed latitudinal/ecotonal gradients in shell morphology for intertidal turban snails (Tegula spp.) are related to variable predator presence. However, long-term physiological responses to predation are difficult to evaluate at a large scale in the field. Thus, it is unclear the extent to which (1) comparatively dilute predator cues experienced by wild snail populations regulate morphometric
development and (2) energetic costs associated with defensive shifts in shell morphology impact other life history traits (e.g., reproduction). The 2013 outbreak of sea star wasting disease in central California provided the unique framework for a long-term natural predator removal experiment comparing shell morphometrics and gonadosomatic index (GSI) of subtidal *Tegula* populations at sites where predatory sea stars were locally extinct (SS-) vs. paired sites maintaining low levels of predator presence (SS+). All three species of snails examined displayed significantly higher proportional allocation to shell mass at SS+ locations and reproduction (GSI) at SS- locations. However, observed shifts in shell morphology differed by species and appeared closely related to species-specific predator avoidance strategies (e.g. evasive maneuvers vs. clamping down on substratum). These results suggest that *Tegula* life history strategies in coastal giant kelp forests may be strongly regulated by predator presence.

**WHAT EVER HAPPENED TO ALASKAN ABALONE? CURRENT INSIGHTS AND HISTORIC COMPARISONS OF PINTO ABALONE POPULATIONS IN SOUTHEAST ALASKA**
† White, T.D.1*; Eckert, G.L.2; Raimondi, P.1

1- University of California, Santa Cruz 2- University of Alaska, Fairbanks College of Fisheries and Ocean Sciences

From Baja California, Mexico to Southeast Alaska, pinto abalone (*Haliotis kamtschatkana*) populations have experienced precipitous declines attributed to loss of habitat, disease, and overfishing. For these reasons and more, management agencies remain concerned for the species across its range. In Southeast Alaska, the history of commercial harvest and reintroduction of sea otters are factors thought to contribute to abalone population decline. However, recent surveys show population growth in the presence of predators, including sea otters. These surveys also find reduced abalone densities in areas of high historic commercial harvest and where predators, like sea otters, remain absent. Since 2015, multiple agencies have worked to address data deficiencies pertaining to abalone in Alaska including: The Alaska Department of Fish and Game, The National Marine Fisheries Service, The Sitka Sound Science Center, and University of California Santa Cruz. Recent comparisons of surveys in Sitka, Prince of Wales (POW), and Ketchikan, Alaska illustrated very different abalone population characteristics. Sitka and Ketchikan sites had the highest abalone densities and closest neighbor distances. In POW, where otters are present, abalone showed increased refuge-habitat use. Current data compared with available historic data revealed that historically there were higher counts and larger abalone at most sites. These comparisons and novel findings provide information key to informed management and a spatially specific depiction of pinto abalone populations across Southeast Alaska.

Session 11: 15 Minute general 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**AN INITIAL, NOVEL MULTIDISCIPLINARY TEST FOR REFLECTIVITY OF MASSES OF AEROSOLS AND LARGER PARTICLES THROUGHOUT THE ATMOSPHERE**

Kitting, C.L.*

* Biological Sciences, Cal State U. East Bay

With inadequate conservation, human disruptions of global ecology require enormous ecosystem restoration breakthroughs to limit such problems as climate disruption. Upper Atmospheric Aerosol Injection has been proposed as emergency measures to cool Earth, but tests will be expensive and could worsen this atmospheric resource. When European Space Agency used NASA’s airborne observatory to monitor destructive reentry of a 20-tonne dumpster, ATV-1, from
International Space Station, I analyzed environmental aspects of this largest injection of particles throughout the atmosphere, to measure reflective properties, persistence, and other atmospheric effects over the remote South Pacific. Interception of the night-time reentry, 100km from the reentry path, allowed tracking reentering debris horizon to horizon, as a lengthening train of man-made meteors. Capturing emission spectra identified ionized components from the 10 tonnes of solid waste (mainly Al), 6 tonnes of sewage (including initially curious Na), and major fragments of titanium (Ti), etc. My diverse parallel instruments detected all ~50 trailing fragments brighter than magnitude ~6 diverging through <1 degree of sky throughout the 2-minute, ~180-degree reentry. An additional aircraft radar test sought a persistent overall vapor trail. But a reflective wake of each fragment was detectable for seconds, only. Analogous, suitable tests are proposed. It appears more logical (but possibly too late) to PREVENT such changes in Earth’s thermal budget and atmosphere rather than relying on extreme, temporary remedies.

RESOURCE PARTITIONING OF AN ECOSYSTEM ENGINEER INCREASES ALGAL DIVERSITY AND PRODUCTION (YOUTUBE)
† Greenhill, M. 1*; Munson, C. 1; Lamb, R. W. 2; Witman, J. D. 1

1- Brown University 2- Woods Hole Oceanographic Institute

Resource partitioning is traditionally associated with increased depletion and exploitation of resources, however, the effects of resource partitioning in habitat modifiers and ecosystem engineers remains widely unstudied. Galapagos damselfish, marine ecosystem engineers, partition spatial and algal resources through differences in depth zonation and the cultivation of distinct algal community compositions within their territories. Here, we test whether resource partitioning exists between three closely related damselfish species in the Galapagos: Stegastes beebei, Stegastes arcifrons, and Microspathodon dorsalis. We then examine the consequences of their partitioning by testing whether algal biomass and rates of primary production vary across damselfish species. Finally, we examine the effects of partitioning on algal resources by comparing biomass and production inside of territories with that of the surrounding substrate, as well as by modeling the relationship between damselfish functional richness, algal biomass, and algal diversity. This study illustrates that the coexistence of these three species, facilitated by partitioning of spatial and algal resources, leads to increased resource availability and diversity due to their role as ecosystem engineers. We propose that increased resource partitioning does not always lead to resource depletion; conversely, partitioning in organisms that have a positive effect on their environment, such as ecosystem engineers, may increase resource availability, rates of resource renewal, and resource diversity.

DE FACTO MPAS CONTRIBUTE TO THE PROTECTION OF CALIFORNIA’S DEEP ROCK HABITATS (YOUTUBE)
Linholm, J. 1*; Starr, R. 2; Esgro, M. 3; Salinas Ruiz, P. 1; Bretz, C. 1

1- Department of Marine Science, CSU Monterey Bay 2- Moss Landing Marine Laboratories 3- California Ocean Protection Council

The conservation benefits of de facto marine protected areas (MPAs), locations in the ocean that minimize or exclude selected anthropogenic impacts for reasons other than conservation, have been quantified at a number of sites around the world. However, these studies have largely been limited to specific sites, leaving the broader potential contribution of de facto MPAs unresolved. As California moves toward the first management review of its statewide MPA network in 2022, we are quantifying the contribution of de facto MPAs relative to the 124 state MPAs with respect to the protection of demersal rocky habitats statewide. Here we report on the results to-date for the
Central Coast (from Año Nuevo to Point Conception). We reviewed 27 published studies that used topographic maps of the seafloor to create habitat suitability models for important demersal rockfishes along the west coast of North America. From that review we extracted four habitat attributes that were key to describing the distribution of rockfishes. The key habitat attributes common across latitudes and fish species included water depth, substrate type, complexity and steepness of slope. We then quantified the area of habitats with those attributes inside the boundaries of 29 MPAs and 16 de facto MPAs in the central coast region, using the highest resolution topographic maps available (2m). Results suggest that de facto MPAs can contribute to conservation of important fished species, however, we expect the relative contributions of de facto vs. state MPAs to vary considerably among regions.

ECOLOGICAL DRIVERS OF PARROTFISH CORALLIVORY ACROSS MULTIPLE SPATIAL SCALES IN THE GREATER CARIBBEAN (YOUTUBE)
† Rempel, H.S. 1*; Barton, E.M. 1; Hale, T.C. 1; Lamore, R.J. 1; Adam, T.C. 2; Burkepile, D.E. 3; Bodwin, K.N 4; Ruttenberg, B.I. 1

†- Biological Sciences Department, California Polytechnic State University, SLO 2- Marine Science Institute, University of California, Santa Barbara 3- Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara 4- California Polytechnic State University, SLO

Parrotfishes are important herbivores that reduce coral-algae competition by grazing algae; yet, some species are also occasional coral predators (corallivores) and thereby have direct negative impacts on predated coral colonies. There is concern that parrotfish corallivory may contribute to declines in targeted coral species in the Caribbean, particularly in areas with high parrotfish biomass and low coral cover. We evaluated how parrotfish grazing intensity varied across multiple spatial scales, from the level of individual coral colonies to reefs, across three regions of the Greater Caribbean – Bonaire, the Florida Keys, and St. Croix. We compared sites spanning broad gradients in parrotfish biomass and percent coral cover, yet found no effect of these variables on grazing intensity within or among regions. This suggests that previous assertions that conservation of corallivorous parrotfishes may have net negative impacts on coral communities are not supported at the reef-scale. Instead, we found that colony-level traits such as coral species and size may be stronger drivers of predation intensity. We found that predation scar size and density increased as colony size increased and found higher levels of grazing intensity on Orbicella annularis, Porites astreoides and Porites spp. finger corals across regions. Therefore, the direct consequences of parrotfish corallivory for coral tissue loss are likely low for the majority of coral species, but further research is needed to better understand the long-term consequences of corallivory for heavily targeted species.

REPEATED GENETIC DIVERGENCE ACROSS TIDAL ELEVATION IN A FOUNDATION PLANT SPECIES (YOUTUBE)
Sotka, E.E. 1*; Zerebecki, R.A. 2; Hanley, T.C. 3; Bell, K.L. 4; Gehring, C. 5; Nice, C.C. 6; Richards, C.L. 7; Hughes, R.A. 3

1- College of Charleston 2- Dauphin Island Sea Lab 3- Northeastern University 4- University of Maryland 5- Northern Arizona University 6- Texas State University 7- University of South Florida

Microgeographic genetic divergence can create fine-scale trait variation, and when such divergence occurs in foundation species, it has the potential for widespread ecological and evolutionary impacts. We tested for microgeographic trait and genetic divergence in Spartina alterniflora, a foundation species that dominates salt marshes of the US Atlantic and Gulf coasts. Spartina is characterized by tall-form (1-2m) plants at lower tidal elevations and short-form (<0.5m) plants at...
higher tidal elevations, yet whether this trait variation reflects plastic and/or genetic responses to these environments remains unclear. In the greenhouse, seedlings raised from tall-form plants grew taller than those from short-form plants, indicating a genetic basis to differences in height. When we reciprocally transplanted seedlings back into the field for a growing season, the surviving tall-origin transplants were taller and had higher above-to-belowground biomass than short-origin transplants in the tall zone, suggesting adaptation of these two ecologically important traits. A survey of single nucleotide polymorphisms across the US revealed strong independent genetic differentiation between tall- and short-form Spartina forms at 5 of 6 tested marshes. The observed microgeographic genetic differentiation of adaptive traits in Spartina have implications for restoration efforts and may contribute to ecosystem resilience and functioning.

EVALUATING THE IMPORTANCE OF REEF-BASED RESOURCES FOR REPRODUCTION IN A TEMPERATE REEF FISH (YOUTUBE)
† Chubak, B.R*; Steele, M.A

California State University, Northridge

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 among them. We measured the prey availability, diet composition, and batch fecundity of California sheephead on three large reefs within the Southern California Bight. Reproductive output, diet, and prey availability all differed between years, implying that variation in prey availability affected diet, which affected reproductive output. Understanding how changes to kelp forest habitat impact reproductive output can aid in future management efforts of economically and ecologically important species of fish.

A TALE OF TWO POOLS: SURFGRASS AND CALIFORNIA MUSSEL REMOVAL ALTERS SHORT-TERM ECOSYSTEM FUNCTIONING WITHIN TIDEPOOL COMMUNITIES (YOUTUBE)
‡ Fields, J.B*; Silbiger, N.J.

California State University, Northridge

Foundation species are organisms that create shelter, enhance biodiversity, and maintain ecosystem functioning within their environment. Within the rocky intertidal ecosystem, a coastal ecosystem dominated by mussels and surfgrass, foundation species are expected to decrease with climate change, extreme climatic events, and increased human impact. However, there is a need to better understand the magnitude of effect of intertidal foundation species loss will have on ecosystem functioning through changes in community structure and resource fluxes using a causal approach. We studied the direct and indirect short-term effects of foundation species loss of mussels (Mytilus californianus) and surfgrass (Phyllospadix spp.) on community structure and resource fluxes via in situ tide pool manipulations. We measured ecosystem function stocks of community structure and fluxes of light, temperature, dissolved inorganic nutrients, pH, and ecosystem metabolism (net ecosystem calcification [NEC] and net ecosystem production [NEP]) in mussel- and surfgrass-dominated Oregon tide pools before and after removal of foundation species. We analyzed changes between before and after period using a structural equation model. Surfgrass and mussel loss caused significant changes in the sessile and mobile communities, increased the light and temperature environment, directly and indirectly increased pH, and ecosystem
metabolism. We demonstrate that foundation species loss had immediate cascading impacts on ecosystem functioning, threatening the ecological services of tidepool systems.

**Comparative transcriptomics identify population specific responses to thermal stress in the eastern oyster.**

Johnson, K.M. 1*; Jones, H.S. 2; Casas, S.M. 2; La Peyre, J.F. 2; Kelly, M.W. 2

1- California Polytechnic State University San Luis Obispo 2- Louisiana State University

The large geographic distribution of the eastern oyster, *Crassostrea virginica* makes it an ideal species to test how populations have adapted to latitudinal gradients in temperature. Despite inhabiting distinct thermal regimes, populations of *C. virginica* near the species’ southern and northern geographic range show minimal population differences in their physiological response to temperature. In this study, we used comparative transcriptomics to understand how oysters from either end of the species’ range maintain homeostasis across three acclimation temperatures (10, 20, and 30°C). With this approach, we have identified genes that were differentially expressed in response to temperature both within and between populations. In addition, we were able to compare single nucleotide polymorphisms (SNPs) between the populations to calculate gene-wide estimates of FST and Ka/Ks ratios. This combined approach found that genes with population-specific responses to temperature had elevated FST and Ka/Ks ratios compared to the genome-wide average. In contrast, genes showing only a response to temperature were found to only have elevated FST values suggesting that divergent FST may be due to selection on linked regulatory regions rather than positive selection on protein coding regions. Taken together our results suggest that, despite coarse-scale physiological similarities, natural selection has shaped divergent gene expression responses to temperature in geographically separated populations of this broadly eurythermal marine invertebrate.

Session 12: 15 Minute general 2

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

**EFFECTS OF ESTUARY-WIDE EELGRASS LOSS ON FISH POPULATIONS IN MORRO BAY, CALIFORNIA (YOUTUBE)**

Jennifer K. O’Leary 1*; Maurice Goodman 2; Ryan K. Walter 3; Karissa Willets 4; Dan Pondella 5; John Stephens 5

1- Wildlife Conservation Society 2- Stanford University 3- California Polytechnic State University 4- Morro Bay National Estuary Program 5- Occidental College

Globally, habitat loss in coastal marine systems is a major driver of species decline, and estuaries are particularly susceptible to loss. Along the United States Pacific coast, monospecific eelgrass (*Zostera marina*) beds form the major estuarine vegetated habitat. In Morro Bay, California, eelgrass experienced an unprecedented decline of >95%, from 139 hectares in 2007 to <6 hectares by 2017. Fish populations were compared before and after the eelgrass decline using trawl surveys. Beach seines surveys were also conducted during the post-decline period to characterize species within and outside of remnant eelgrass beds. While the estuary-wide loss of eelgrass did not result in fewer fish or less biomass, it led to significant changes in species composition, with winners and losers in the fish community. The post-eelgrass decline period was characterized by increases in flatfish (mainly *Citharichthys stigmaeus*) and staghorn sculpin (*Leptocottus armatus*), and decreases in habitat specialists including bay pipefish (*Syngnathus leptorhynchus*) and shiner perch (*Cymatogaster aggregata*). There were similar trends inside and outside of remnant eelgrass patches. These findings support evidence across multiple ecosystems suggesting that the
predominance of habitat-specialists will predict whether or not habitat loss leads to an overall decline in fish abundance. In addition, loss of critical habitats across seascapes can restrict population connectivity and lead to range contraction, and this is likely to effect bay pipefish.

**GROWTH, FECUNDITY, AND COMMERCIAL VIABILITY IN DYNAMIC RED & PURPLE SEA URCHIN BARRENS** *(YouTube)*

Okamoto, D.K. 1*; Spindel N 1; Reed, D.C. 2; Galloway, A.G. 3; Lee, LC 4

1- Florida State University 2- UCSB 3- University of Oregon 4- Parks Canada

Sea urchins in the northeast Pacific are culturally, ecologically, and economically important. They are also capable of both denuding nearshore ecosystems while coping with resulting declines in food supply. We used two sea urchin species with different longevities to illustrate how rapid changes in sea urchin density affect kelp productivity that in turn alters rates of urchin growth, commercially valued gonadal energy reserves, and fecundity. We first show how volatile purple sea urchin populations can rapidly increase in abundance in response to climate-related recruitment that can devastate previously productive kelp forests. This change triggers dramatic declines in gonad reserves and leads to a collapse in individual and population level egg production. In contrast to purple sea urchins, red urchins exhibit low recruitment, greater longevity, and form barrens that can persist for decades. We reveal how food deprivation for red urchins causes a size-specific decline in growth, gonadal reserves, and commercial value. For both species, experimental feeding or starvation can quickly result in gonadal recovery or emaciation. Finally, we show how a collaborative, large-scale experimental kelp forest restoration (~3 km of coastline) can quickly lead to recovery in these metrics. Collectively, our results combine modeling, large-scale field experiments, laboratory experiments, mark-recapture, and long-term monitoring to illustrate how feedbacks in sea urchin-kelp interactions create impacts that affect ecosystems and both indigenous and commercial fishing communities.

**ZOMBIES OF THE NEARSHORE: METABOLIC DEPRESSION IN SEA URCHIN BARRENS ASSOCIATED WITH FOOD DEPRIVATION** *(YouTube)*

† Spindel, N.B. 1*; Lee, L.C. 2; Okamoto, D.K. 1

1- Florida State University, Department of Biological Science 2- Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site, 60 Second Beach Road, Skidegate, British Columbia, Canada

Sea urchins exhibit remarkable tolerance for food deprivation and capacity for recovery from emaciation. Yet metabolic processes that give rise to such resistance and resilience to nutritional stress remain untested. We conducted field sampling and laboratory experiments to test hypotheses regarding how urchins alter diet and metabolism to cope with food limitation in urchin barrens. Size-specific metabolic depression was detected in wild individuals collected from barrens relative to those from kelp forests. This pattern was readily reversed by feeding urchins from barrens in that body condition and metabolic rates quickly recovered. Likewise, starving urchins from kelp forests led to dramatic reduction in metabolic rate and a decline in body condition. Therefore, starvation was likely the factor responsible for driving metabolic depression. Importantly, metabolic rate was depressed beyond that expected from proportional changes in soft tissue mass in both urchins from barrens and those which were experimentally starved. This result suggests that changes in body mass alone cannot explain shifts in metabolism and that changes in cellular metabolism may play an important role in urchins’ starvation resistance. Barren urchins and kelp forest urchins exhibited no difference in feeding rate or assimilation efficiency. These results indicate that urchins exhibit remarkable metabolic plasticity that may help them cope with
prolonged periods of food deprivation, but strong resilience in consumptive capacity that likely contributes to the persistence of barrens.

EXOSKELETAL COMPONENTS INCREASE THE MECHANICAL PROPERTIES AND THERMAL STABILITY OF CRABS LIVING IN THE DEEP-SEA HYDROTHERMAL VENT (YOUTUBE)
† Cho, B.1; Kim, D. 2; Kim, T. 1

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Hydrothermal vents are mainly located at the divergent boundary of deep sea floors. In this area, the temperature fluctuation is very extreme ranging from approximately 0°C to 400°C. In order to explore the exoskeleton characteristics of crabs (Austinograea rodriguezensis) that made it possible to adapt to severe environments in the Indian Ocean hydrothermal vent, we conducted a comparative analysis with the Asian paddle crab (Charybdis japonica) living in coastal areas of South Korea. Scanning electron microscope (SEM), energy dispersive x-ray (EDX), Raman spectrometer, nanoindenter, and thermal gravimetric-differential thermal analyzer (TG-DTA) were used for analyzing the structure, surface components, the compound of components, mechanical properties, and thermal stability, respectively. As a result of structure analysis, the main structures (e.g. multilayer, granule, and Bouligand structures) were similar in both species. However, in the analysis of the components, there were significant differences in the ratio of compound and distribution of elements. Especially, the proportion of aluminum element and organic matter constitute the epicuticle of exoskeleton were higher in the hydrothermal vent crab than in the paddle crab. These might have improved the mechanical properties and thermal stability of hydrothermal species, which are higher than those of the coastal species.

HUMAN TRAMPLING DECREASES SURFACE ACTIVITY AND MALE COURTSHIP BEHAVIOR OF THE FIDDLER CRAB, Austruca lactea (YOUTUBE)
† Park, S.1*; Seo, H. 2; Jo, K. 2; Lee, Y. 2; Kim, T. 1

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As growth of human recreational visits to the tidal flat increases trampling pressure on the tidal flat, it may induce significant changes in the coastal benthic ecosystem. The fiddler crab Austruca lactea, living in the upper intertidal region, are active on the surface during low tide and reproduces during the summer. Not only the habitat vulnerability to human activities but also the limited reproduction period during summer may induce population decrease in temperate regions such as Japan and South Korea. We performed three experiments to elucidate effects of trampling on behaviors of A. lactea. In the first experiment, we observed the number of crabs active on the surface after trampling the tidal flat at 3 different intensities for 35 days. Population densities of crabs active on the surface and that of courting males significantly decreased at both trampling treatments after trampling events. In monitoring per week after trampling period, the density of active individuals did not fully recover until sixth week. Lastly, individual focused experiment through video recording showed that reemergence time of crabs of which burrow opening got trampled was also significantly delayed. Especially, courting males took twice as much time to reemerge from their burrow after trampling as non-courting males did. Our results demonstrated that trampling on the
coastal region disrupted timing of behaviors of crabs and male reproductive behavior on the surface, and thus may ultimately impact on the population dynamics of *A. lactea*.

**Resilient consumers accelerate the decomposition process in a naturally acidified seagrass ecosystem**  
Lee, J.¹; Micheli, F. ²; Gambi, M.C. ³; Munari, Marco ³; Kroeker, K.J. ⁴

1- Marine Science Center, Northeastern University 2- Hopkins Marine Station, Stanford University 3- Laboratory of Functional and Evolutionary Ecology, Stazione Zoologica Anton Dohrn 4- Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Climate stressors are predicted to alter biodiversity and ecosystem functions worldwide. However, scaling up their effects from species to ecosystems poses a major challenge, as species and functional groups can exhibit different capacities to adapt and acclimate to changing environments. We utilized naturally acidified seagrass habitats (*Posidonia oceanica*) near volcanic CO₂ vents (Ischia Island, Italy) to examine how ocean acidification influences a vital ecosystem function in coastal vegetated habitats (decomposition of plant primary production) by modifying consumer assemblages (seagrass detritivores). Using an experimental litterbag approach, we quantified seagrass decomposition rates across distinct pH zones associated with study vents (ambient, low, extreme low pH). We found that decreasing pH significantly reduce the detritivore taxonomic diversity but variably affect species abundance. Specifically, the density of dominant and functionally important detritivores (amphipod *Gammarella fucicola*) increased under acidification, whereas the abundance of other less common species decreased. The total detritivore abundance more than tripled with acidification, and these changes were also associated with increased detritivory (~ 130%) and accelerated decay of seagrass detritus (~ 65%). Our findings suggest global stressors such as ocean acidification have a major potential to restructure consumer communities and modify the functioning of and services provided by coastal blue carbon ecosystems, such as nutrient cycling and carbon sequestration.

**WHAT'S THAT IN MY H2O NO! CONTAMINANT TYPES AND EFFECTS IN NORTHWEST AQUATIC SPECIES (YOUTUBE)**
Granek, EF*; Baechler, BR; Ehrhart, AL; Scully Engelmeyer, K; Tissot, A

*Portland State University*

Nearshore marine organisms experience an array of natural and anthropogenic stressors that affect their growth, reproductive capacity, and fitness, yet we lack a holistic understanding of the combined effects of these diverse variables. Though some research has examined multiple stressors, the staggering number of contaminants entering aquatic systems from diverse land uses makes it difficult to quantify the additive or synergistic effects of such exposure, let alone the interactions with environmental stressors. For example, West Coast estuarine and nearshore species are exposed to herbicides and pesticides from agriculture and forestry, pharmaceuticals and personal care products from urban and rural areas, heavy metals from industry, and microplastics from an array of sources including household greywater, wastewater, septic systems, agricultural field biosolid applications, stormwater and industry. We have quantified these contaminants in field-collected freshwater mussels, estuarine oysters, and marine clams from Oregon and Washington. Through laboratory exposure studies, we have elucidated effects of some compounds on feeding rates, growth, and fitness. The unknown synergistic effects of the array of compounds
found in marine ecosystems, coupled with climate-related temperature and pH changes have unknown combined effects on aquatic communities and warrant both further study and management consideration.

**PLASTIC INGESTION BY FRESHWATER TURTLES AND A CALL TO ACTION** *(YOUTUBE)*

Clause, A.G. 1*; Celestian, A.J. 2; Pauly, G.B. 1

1- Urban Nature Research Center & Department of Herpetology, Natural History Museum of Los Angeles County 2- Department of Minerology, Natural History Museum of Los Angeles County

Plastic pollution, and especially plastic ingestion by animals, is a serious global issue. This problem is well documented in marine systems, but it is comparatively understudied in freshwater systems. For turtles, it is unknown how plastic ingestion compares between marine and non-marine species. We review the relevant turtle dietary literature, and find that plastic ingestion is reported for all 7 marine turtle species, but only 5 of 351 non-marine turtle species. In the last 10 years, despite marine turtles representing just 2% of all turtle species, almost 52% of relevant turtle dietary studies involved only marine turtles. These results suggest that plastic ingestion might be an underappreciated threat to non-marine turtles. We also examine plastic ingestion frequency in a freshwater turtle population, finding that 7.7% of 65 turtles had ingested plastic. However, plastic-mimicking organic material would have inflated our frequency results up to 40% higher were it not for verification using Raman spectroscopy. Additionally, we showcase how non-native turtles can be used as a proxy for understanding the scope and severity of plastic ingestion in native turtles of conservation concern. As a call to action, we conclude with recommendations for how scientists studying non-marine turtles can improve the implementation, quality, and discoverability of studies on plastic ingestion.

**AN UNEXPECTED SNACK: ZOOPLANKTON FEEDING ON MICROPLASTICS IN THE NORTHERN CALIFORNIA CURRENT** *(YOUTUBE)*

Bolm, A.E. 1*; Granek, E.F. 2; Miller, J.A. 1; Brander, S.M. 1

1- Oregon State University 2- Portland State University

Microplastics are ubiquitous in our oceans, yet we are still clarifying what risks they pose to marine organisms. Lab studies have more frequently used smooth, often virgin microbeads when testing the effects of microplastics on organisms, though tangled fibers and jagged fragments are more commonly found in the ocean and have different impacts when ingested. Thus, the disconnect between plastics used in laboratory studies from those found in the environment is problematic. This study quantifies and characterizes microplastics in wild-caught zooplankton to help inform future lab studies assessing risk. In 2019, we collected 39 plankton tows from 3 - 200 nautical miles offshore between Trinidad Head, California and Cape Meares, Oregon, within the Northern California Current (NCC). The NCC is both highly productive and lacks microplastics occurrence data. These data provide a baseline for the types of microplastics ingested by NCC zooplankton genera, including amphipods, copepods, chaetognaths, larval fish, crab megalopae, and euphausiids. By identifying the types and quantity of microplastics zooplankton groups are ingesting in their environment, future lab studies can more accurately assess the risks associated with microplastic ingestion.

**ABUNDANT, SMALL ANTHROPOGENIC MICROPARTICLES ARE BIOAVAILABLE TO A WIDE RANGE OF ZOOPLANKTON TAXA IN THE SOUTHERN CALIFORNIA BIGHT** *(YOUTUBE)*

Steele, C.L.*; Marovitz, M.

*California State University, Channel Islands*
Anthropogenic microparticles are commonly found in nearshore environments, including along the California coast. These microparticles include small (<5mm), plastic items that have been manufactured as microplastics or have formed from the weathering and breakdown of larger plastics. These particles are bioavailable to a variety of marine species, including zooplankton, and can bioaccumulate through trophic levels. To examine the nearshore distribution of microparticles and zooplankton, we used a 30L Schindler-Patalas plankton trap to sample fifteen different pier and harbor locations in Southern California. Zooplankton taxa and microparticle type and size were estimated within each sample. At each location a variety of zooplankton taxa and microparticles of a size that would be bioavailable to them co-occurred. The size distribution of zooplankton was statistically significantly different between pier and harbor sites (D = 0.16, p = 0.012), with pier sites having a higher frequency of plankton in the smaller 0.2 - 0.4mm size range. The size distribution of microparticles did not differ significantly between pier and harbor locations (D = 0.088, p = 0.11). There were predominantly more abundant smaller microplastics (0.0 mm - 0.3 mm) at both piers and harbors, which overlapped the size distribution of small zooplankton present (0.1 mm – 0.5 mm). These findings indicating the high abundance of very small and bioavailable microparticles are concerning because of the potential impact to nearshore communities at multiple trophic levels.

ANTHROPOGENIC MICRODEBRIS ALONG AN URBAN MARINE WATERFRONT-QUANTIFYING MICROFIBERS SEASONALLY (YOUTUBE)
Smith, A.*; Damazo, L.; Larson, S.

Seattle Aquarium

The Seattle Aquarium sits over Elliott Bay along downtown Seattle’s waterfront. The Aquarium draws in approximately 10,000 liters per minute of Elliott Bay water from depth to fill exhibits containing over 2000 marine species including invertebrates, fish, seabirds and mammals. In 2019 the Aquarium initiated a microdebris research project to document the amount of anthropogenic debris brought into our exhibits from Elliott Bay. The Aquarium research lab began semi-monthly sampling of our incoming saltwater both pre and post sand filtration. This allowed us to measure the amount of anthropogenic debris coming into the aquarium and to determine how much debris was moving past our sand filters and thus how much debris our animals experienced. We sampled 100 liters of raw and filtered saltwater, processed samples in a clean laminar flow hood alongside procedural blanks, separated the microdebris from the water using density separation with oil extraction, and vacuum filtered the microdebris onto a 1 micron cellulose filter paper for eventual counting under a high-powered microscope. Results show that our sand filters remove a significant amount (over half) of the incoming microdebris, and that the amount of debris is seasonal, with significantly more anthropogenic microdebris in the wet season (October-March) compared to the dry season (April-September). This makes sense, as the Aquarium inflow is subject to greater amounts of freshwater input from both nearby rivers (e.g. the Duwamish) as well as surface and other runoff from the City of Seattle during the rainy season.

INGESTION OF MICROPLASTICS BY NORTH AMERICAN OTTERS USING SCAT AND DIET ANALYSIS (YOUTUBE)
Van Brocklin, J.E. 1*; Brander, S.M. 1; Larson, S. 2; Levi, T. 1; Duplaix, N. 1

1- Oregon State University 2- Seattle Aquarium

Sea otters act as valuable indicators of ecosystem health and consume prey items that have been shown to contain microplastics. As such, we are investigating the ingestion of microplastics by sea otters (Enhydra lutris) in the North Pacific using scat. Our study includes samples from ex-situ and
in-situ individuals and analyzes otter prey items for microplastic particles in order to evaluate the role trophic transfer may have in microplastic ingestion by these otters. This analysis could provide opportunities to understand the current level of microplastic ingestion by wild sea otters in using a non-invasive method, which may be beneficial for understanding sea otter population health.

RESPONSE OF THE SYMBIOTIC SEA ANEMONE ANTHOPLEURA ELEGANTISSIMA TO MICROPOLASTICS
‡ Beck, R.I.*

Western Washington University

The Salish Sea, a large and complex fjord estuary, receives waters impacted by a watershed that includes an estimated 8 million people aggregated in several large urban and industrial centers. Microplastics, defined as plastic particles less than 5 mm, are transported from these watersheds into the Salish Sea where they are easily ingested by filter feeders, herbivores and predators. To measure effects of microplastics on one common and important intertidal species, we exposed sea anemones, A. elegantissima, to polyester microfibers in one of three size categories at concentrations of either 0.01 g/L or 0.1 g/L. Anemones were repeatedly measured before and during an exposure period of four weeks. We used a mixed modeling approach to analyze A. elegantissima performance (oral disc diameter, respiration rate, symbiont density, symbiont mitotic index, and photosynthetic efficiency). We found that, while anemone response changed over time in general, anemones given microplastic treatments significantly differed from a control group only in oral disc diameters and mitotic index of the symbionts. The results suggest that, under the experimental conditions we used, short-term effects of microplastic exposure to a resilient intertidal species are not large but may have more lasting impacts over time with the complex characteristics and increasing amount of microplastic marine debris.

EFFECTS OF MIRCOPLASTIC EXPOSURE ON GROWTH AND SURVIVAL OF LARVAL CALIFORNIA GRUNION
† Chhor, J.T.*; Johnson, D.

California State University, Long Beach

Microplastics have been found in all marine environments and there is growing concern because of their potential to affect marine organisms. Microplastics can leach chemicals into the environment and be consumed by marine organisms. Both pathways may have negative effects on growth or survival. Studies on the larvae of marine species will be important because larval stages may be more sensitive to exposure than their adult counterparts. However, few fish species have been investigated thus far. To further investigate the potential effects microplastics have on larval fishes, we exposed California grunion (Leuresthes Tenuis) to both virgin and environmentally exposed polyethylene microplastics and their leachates. We used three different concentrations to investigate whether any responses were dose dependent. We found that grunion survival was not significantly different among treatments. We also found that grunion larvae exposed to the highest concentration of virgin microplastics grew faster than controls and that larvae may alter their feeding behavior in response to microplastics and their leachates. Our results suggest exposure may not have major effects on larvae within 10-days post-hatch but hint at consequences that may manifest in older larval or juvenile grunion.

THE SPATIAL DIFFERENCE IMPACTING THE PRESENCE OF INGESTED MICROPOLASTICS IN SEBASTES MELANOPS OFF THE OREGON COAST (YOUTUBE)
† Lasdin, Katherine, S*; Brander, Susanne, M
Microplastics, a type of plastic debris, is common in the marine environment. Rockfish *Sebastes spp* are opportunistic feeders, potentially increasing their vulnerabilities to the presence of potential plastics in marine waters. Black rockfish *Sebastes melanops* from four Oregon marine reserves and a town (Newport, OR) will be examined for the presence of microplastics. Determining whether there is a difference in the amount/sizes of plastics in the reserves and from the port town in important as the reserves are less than 10 years old and they will be reviewed in 2023. Through a variety of methods, the gastrointestinal tract organ and the contents will be digested and examined separately for the presence of suspected plastics. The percent rockfish containing suspected plastics from analyzed data, shows that those associated with the port town was 10.3% and the marine reserves were 26.7%. Thus far, the marine reserve fish contain more suspected plastics than those from the town (p-value = 0.016). Using micro-Fourier transform infrared spectroscopy, suspected plastics will continue to be analyzed for further identification. Additional research needs to be completed to determine the impacts of plastics, the amount in Pacific Northwest waters and the impacts to the food web.

**MARINE MUSSEL BIODEPOSITS: THE UPS AND DOWNS OF MICROPLASTIC**

† Harris, Lyda¹; Gill, Harsimran ²; Carrington, Emily ²

¹- University of Washington; Seattle Aquarium ²- University of Washington

Microplastic (MP; plastic < 5mm) is ubiquitous in marine environments and is likely transported from surface waters to bottom habitats by biotic benthic-pelagic coupling. Mussels are key benthic-pelagic couplers, removing and concentrating particles from the water column into dense and nutrient rich biodeposits, thus linking the bottom substrate (benthic) to the water column (pelagic). This study examined how MP affects benthic-pelagic coupling processes of marine mussels by measuring clearance rate as well as four attributes of biodeposits (feces and pseudofeces) from feeding regimes with and without MP: 1) morphology, 2) quantity of algal and MP particles, 3) sinking rate, and 4) resuspension rate. Clearance rate decreased by 62% at high MP concentrations (>1,250 particles/ml). Biodeposits from the algae treatment contained more algal cells than biodeposits from the MP treatment and pseudofeces contained more MP particles than feces. Biodeposits from the MP treatment sank 34-37% slower and resuspended in 7-22% slower shear velocities than biodeposits from the algae treatment. These findings suggest high MP concentrations inhibit mussel clearance rate, more than expected by changes in particle concentration. Further, decreases in sinking rate and resuspension velocities of biodeposits containing MP may result in increased dispersal distances. Algal and MP particles may thus be transported further away from the mussel, decreasing in in-bed particle and nutrient input and increasing nutrient subsidies for other benthic and pelagic communities.

**A FOCUS ON NANOSCALE PLASTICS POLLUTION AND THE POTENTIAL FOR ECOTOXICOLOGICAL CONSEQUENCES**


*Oregon State University*

Reports of microplastics in the water that we drink and the air that we breathe are ever-increasing. Plastics have been reported in nearly every environment in the world, and estimates put the total number of microplastics in the trillions. However, this may very well be an underestimate of plastic pollution as a whole. The reason is because once microplastics are further reduced in size, they
nominally enter the nanoscale (<1000 nm), where they cannot be seen by the naked eye or even with the use of a typical laboratory microscope. Thus far, research has focused on plastics in the macro- (> 25mm) and micro-size (< 5mm) ranges, which are easier both to detect and identify, leaving large knowledge gaps in our understanding of nanoplastic debris. We do know from the field of nanotoxicology that features such as size, shape, and surface chemistry can have significant impacts on uptake, translocation and ultimately toxicity. This talk will focus on the many existing gaps in our knowledge of nanoplastics behavior starting with an educational video from the Pacific Northwest Consortium on Plastics and Oregon State University's Marine Studies Initiative. We will also share some of our recent research findings on toxicological responses that are dependent on particle size and plastic type, their behavior in exposure media ranging from freshwater to marine, examined in numerous ecologically important aquatic species.

ECOLOGICAL RISK ASSESSMENT OF MICROPLASTICS IN THE SAN FRANCISCO BAY USING A BAYESIAN NETWORK FRAMEWORK (YOUTUBE)
† Sharpe, E.E.; Landis, W.G.

Western Washington University

Micro- and nano- plastics are a complex and abundant emerging contaminant. Recent advancements in monitoring technology have allowed us to see that plastic particles are widely distributed in the environment. Increased public interest in this topic indicates a need for a comprehensive ecological risk assessment on the environmental impacts of microplastics. This study aims to conduct an ecological risk assessment for micro- and nano- plastics using a Bayesian Network relative risk framework and the San Francisco Bay as a case study. The data that are currently available on microplastics has yet to be applied to management strategies of microplastics in the environment and previous risk assessments for microplastics are limited in scope or inadequate due to the methods they used to calculate risk. The Bayesian Network relative risk model has proven in past studies to be a successful framework for ecological risk assessment, allowing for the creation of a model with predictive capability and adaptive potential as new data becomes available. Using microplastic abundance data collected by the San Francisco Estuary Institute, microplastic toxicity data generated by Oregon State University, and water quality and chemical monitoring data, risk due to microplastics are determined. This study will lay the groundwork for future risk assessments of micro- and nano- plastics in the environment and help to identify key uncertainties that need to be addressed. This work is supported by a National Science Foundation grant (1935018).

EXPLORING BIOPHYSICAL LINKAGES BETWEEN FORESTRY PRACTICES AND FRESHWATER AND ESTUARINE BIVALVES IN THE COAST RANGE OF OREGON (YOUTUBE)
† Scully-Engelmeyer, K.M.; Granek, E.F.; Nielsen-Pincus, M.

1- Portland State University 2- Portland State University

Understanding cross-ecosystem processes and effects of terrestrial/riverine conditions on marine species is a challenging but essential step in designing effective and comprehensive land-sea planning, management, and conservation. Exposure to runoff from pesticides has the potential to disrupt hormonal, reproductive, and developmental processes in aquatic organisms. Non-point sources of pollution are difficult to trace and hard to quantify due to the transient nature of the contamination, but exposure can be explored by examining bioconcentration and passive water sampling. In Oregon, U.S.A., state and federal forestry pesticide regulations differ in buffer size and aerial spraying but both are designed to meet regulatory requirements for water quality. We collected soft-shell clams (Mya arenaria), Pacific oysters (Crassostrea gigas), and Western Pearlshell
mussels (*Margaritifera falcata*) in estuaries and rivers along the Oregon Coast for analysis of forestry-specific chemical compounds. We examined concentrations of compounds in tissues and passive water samples to determine variation in levels and types among watersheds of varying gradients of land use, ownership, and management practices. We observed a variety of herbicides, fungicides and insecticides in bivalve tissue samples as well as correlations between planned herbicide applications and passive water samples. Identifying the relationships between land use and chemical exposures provide insight into effectiveness of current management practices in controlling transport of potentially harmful compounds.

**USING BEHAVIOR TO ASSESS THE SUBLETHAL EFFECTS OF PYRETHROID EXPOSURE AT DIFFERENT SALINITIES IN ESTUARINE FISH (YOUTUBE)**

† Hutton, S.J.¹; Pedersen, E.I.¹; Siddiqui, S.¹; Segarra, A.²; Hladik, L.M.³; Connon, R.E.²; Brander, S.M.¹

1- Oregon State University 2- University of California, Davis 3- U.S. Geological Survey

Behavioral changes in fish can be a strong indicator of sublethal effects of exposure to environmental toxicants. Previous studies have shown that early life exposures to pyrethroid pesticides cause toxic effects at environmentally relevant concentrations, such as reduced hatching and alterations in behavior. This is of concern since a Total Maximum Daily Load for six pyrethroids was recently establish for the San Francisco Bay Delta (SFBD). As climate change progresses salinity intrusion is expected to worsen making differences in toxicity across a salinity gradient important when assessing risk to estuarine species. Inland Silverside (*Menidia beryllina*) is a model estuarine fish found in the SFBD and is commonly used as a surrogate for at risk and endangered fish species, such as Delta Smelt (*Hypomesus transpacificus*). As such, we have exposed Inland Silversides and Delta Smelt at early life stages to environmentally relevant concentrations of pyrethroid pesticides at three different salinities (0.5, 2, 6 ppt). Here we present our results from analysis of behavioral changes in these two fish species between salinity and pyrethroid chemicals. Based on results from related work, we hypothesize that as salinity increases, behavioral changes due to pyrethroid exposure may also increase. These data will provide knowledge to managers and environmental planners to help further protect threatened and endangered fishes in the SFBD.

**CLAMITY: THE SILENT VICTIMS OF FORESTRY USE PESTICIDES (YOUTUBE)**

† Tissot, A.G.¹; Granek, E.F.¹; Hladik, M.L.²; Moran, P.W.²; Scully-Engelmeyer, K¹; Thompson, A.W.¹

1- Portland State University 2- USGS

The US forestry industry commonly applies an array of pesticides to control plant and insect pests. A recent study confirmed the presence of these pesticides in water as well as the tissues of various bivalve species in Oregon coastal watersheds. Though studies have been carried out to determine the individual effects of these compounds on organisms and the environment in which they live to establish lethal limits, environmentally relevant concentrations of these chemicals in combination have not been tested for sub-lethal effects. We conducted laboratory experiments to examine the effects of four commonly used forestry pesticides; Atrazine, Hexazinone, Indaziflam, and Bifenthrin, on the soft shell clam *Mya arenaria*, a common estuary species. Growth, feeding rates, reproductive index and condition index were measured, as well as mortality. Initial results indicate effects of some combinations on clam mortality, even at environmentally relevant concentrations.

**Comparison of Bioconcentration and Kinetics of GenX in Tilapia Oreochromis mossambicus in Fresh and Brackish Water (YOUTUBE)**

Siddiqui, S.¹; Fitzwater, M.²; Scarpa, J²; Brooks, B.³; Conkle, J.L.²
The contaminants of emerging (CEC) concern are causing issues from bioaccumulation in aquatic organisms to drinking water contamination. GenX is one of the CEC occurring in the environment since it replaced other longer carbon chain PFCs, however with improved technology and analysis system, it is more frequently detected and studied by the researchers. High concentrations of GenX identified in surface waters including estuaries raises the concern to understand its mechanism and fate in the aquatic ecosystem. In this study one of the aquacultured fish, Tilapia has been studied for the GenX bioconcentration, half-life and distribution in whole fish as well as different tissues at two salinities (0 and 16), representing freshwater and estuarine environment. The bioconcentration was in decreasing order of Plasma > Liver > Carcass > fillet, with higher distribution in Liver followed by carcass and fillet. The bioconcentration in all the tissues increased with increasing salinity, raising concern for marine organisms. The fillet was found to have the highest half-life followed by carcass, plasma, and liver. The rate of uptake and depuration was positively correlated with the salinity.

Session 14: Special Session: Climate-change refugia

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

**MARINE MICROCLIMATES AS CLIMATE CHANGE REFUGIA IN KELP FOREST ECOSYSTEMS**

Woodson, C.B.*; Micheli, F. †; Boch, C.A. †; Espinoza, A. †; Hernandez, A. †; Torre, J. †

1- University of Georgia 2- Hopkins Marine Station of Stanford University 3- affiliation not listed 4- Comunidad y Bioversidad

Marine microclimates, analogous to terrestrial microclimates, appear to be common features of kelp forest ecosystems. Kelp forest ecosystems often experience large fluctuations in temperature, pH, and dissolved oxygen driven by coastal physical processes. Coastal circulation patterns associated with tides, winds, and coastline orientation can vary at scales as small as 1 km creating very different habitats. At these relatively small spatial scales, kelp and associated fauna respond to environmental changes differently in large-scale forcing leading to a mosaic of environments throughout the range of kelp forest ecosystems along the Northeastern Pacific coast. Incorporation of marine microclimates into conservation and adaptation plans will reduce risk in the face of future climate change.

**Restoring local climate heterogeneity to assist the climate tracking of dispersal-limited species**

Backus, G.A.*; Baskett, M.L.

University of California, Davis

Many dispersal-limited species are likely to face extinction if they lag behind projected rates of rapid climate change. Anthropogenic homogenization of landscapes is likely to increase the projected climate velocity, requiring species to disperse further to reach future analogous climates. To explore how local heterogeneity affects a species’ ability to persist through climate change, we modeled climate-tracking of randomized species in a stochastic, heterogeneous metapopulation. We found that species were more likely to persist in environments with higher local heterogeneity and lower environmental stochasticity. Restoring local heterogeneity prior to climate change helped most species’ chances of persisting through climate change, except for some species with higher dispersal ability, narrower niche breadth, and lower reproductive rates. Our results suggest that
heterogeneity restoration could create refugia-like conditions which could act as an effective local alternative to larger-scale conservation strategies like assisted migration.

**A CASE STUDY FOR CLIMATE CHANGE REFUGIA CONSERVATION IN THE SIERRA NEVADA (YOUTUBE)**

Balantic, C.M.¹; Adams, A.J. ²; Vernon, M.E. ³; Sawyer, S.C. ⁴; Mazur, R.L. ⁵; Gross, S.E. ⁴; Mengelt, C. ⁶; Morales, J. ⁷; Tucker, J.M. ⁴; Thorne, J.H. ⁸; Brown, T.M. ⁹; Athearn, N.D. ⁵; Morelli, T.L. ¹⁰

¹- Northeast Climate Adaptation Science Center, Department of Environmental Conservation, University of Massachusetts Amherst ²- Earth Research Institute, University of California Santa Barbara ³- Point Blue Conservation Science ⁴- USDA Forest Service, Pacific Southwest Region ⁵- National Park Service, Yosemite National Park ⁶- U.S. Fish and Wildlife Service ⁷- Climate Change Program, California Department of Water Resources ⁸- Department of Environmental Science and Policy, University of California, Davis ⁹- Ecology and Evolutionary Biology, University of California, Santa Cruz ¹⁰- U.S. Geological Survey, Northeast Climate Adaptation Science Center, Department of Environmental Conservation, University of Massachusetts Amherst

Climate change uncertainty poses serious challenges to conservation efforts. From a management perspective, one emerging conservation strategy is to identify and manage climate change refugia: areas relatively buffered from contemporary climate change that enable persistence of valued resources. Theory, concrete examples, and a maturing body of literature in refugia science are enabling the translation of refugia conservation into practice. Here, we describe a case study moving toward operationalizing climate change refugia conservation in the Sierra Nevada (California, USA). Structured within the framework of the Climate Change Refugia Conservation Cycle, we identify a preliminary suite of conservation priorities for the ecoregion, as well as a sample of existing mapping, data, tools, and applications that can be leveraged for identifying, prioritizing, managing, and monitoring refugia. This pilot overview of concepts and resources is intended to provide a foundation of ideas for near-term implementation, as well as to stimulate additional collaboration in planning for climate change refugia conservation in the Sierra Nevada.

**FINDING THE ‘SAFE SPACES’ FOR ABALONE ON THE PACIFIC COAST OF BAJA CALIFORNIA, MEXICO: SCALING UP FROM LOCAL HABITAT (YOUTUBE)**

Provost, M.M.¹; De Leo, G. ¹; Micheli, F. ²; Woodson, C.B. ³

¹- Hopkins Marine Station, Stanford University ²- Hopkins Marine Station and Center for Ocean Solutions, Stanford University ³- University of Georgia

Environmental variability in coastal oceans is increasing and extreme events are becoming more frequent with climate change. Understanding the capacity of harvested marine species to withstand the increase in environmental variability is important because of the impacts on fishing communities that depend on these marine resources for their livelihood and wellbeing. We study the biological consequences of environmental variability and extreme events for abalone on the coast of Baja California, Mexico over a decade. We show the extent of two important habitat characteristics: 1) variability in ocean temperature and 2) kelp deforestation on abalone stress and persistence. By accounting for physiological acclimatization, the process by which abalone adjust their physiology to maintain function under prevailing environmental conditions, we translate variable ocean temperatures into a time series of abalone stress. Kelp forests provide food and prolonged deforestation can negatively impact abalone growth, survival and reproduction. Using satellite images, we show where on the coastline kelp biomass has remained consistently low. Combining temperature-induced stress levels and frequency of prolonged kelp absence events at
relatively small spatial scales (~1 km), we show where the abalone ‘safe’ and ‘risky’ habitat is along the Baja coastline.

**INVESTIGATING THE SPATIAL PATTERNING OF CORAL RELATEDNESS ACROSS AN URBAN REEF ENVIRONMENT** *(YOUTUBE)*

Ruiz-Jones, L.J. 1*; Caruso, C. 2; Rocha de Souza, M. 2; Hobbs, C. 3

1- Chaminade University of Honolulu 2- Hawaii Institute of Marine Biology 3- University of York

Kaneohe Bay is Hawaii’s largest bay and home to several of the most abundant reef-building coral species across the found across the Main Hawaiian Islands. The bay has historically been heavily impacted by anthropogenic sources, such as dredging, input of sewage, and invasive algae. In contemporary times, the bay is regularly frequented by fishers and tourists. Kaneohe Bay is also a spatially heterogenous mosaic, making it an ideal place to examine the association between genotypic diversity, phenotypic variation, and environment across space. During the recent global bleaching event variation in individual response was observed within species and adjacent colonies. Despite these various stressors, coral abundance in the bay remains relatively high compared to nearby reefs, especially on the south shore. These spatially heterogenous mosaics might be useful sources of corals for restoration. Data on genotype uniqueness when selecting reef restoration stock helps to preserve genetic diversity. In our study we seek to gain insight into how environmental conditions influence population structure and persistence of specific genotypes of *Montipora capitata*, a potential restoration species. Using temperature loggers, sedimentation traps, and water flow meters, we characterized 30 sites and systematically sampled 600 colonies across the bay. With reduced representation genome sequencing we are investigating relatedness. We are developing a seascape map with genetic, phenotypic, and environmental information that can assist in understanding the relationship between the three.

**MAPPING BULL KELP REFUGIA AND THE ENVIRONMENTAL DRIVERS OF THEIR RESILIENCE ALONG THE NORTH COAST OF CALIFORNIA**

† Cavanaugh, K.C. 1*; Cavanaugh, K.C. 1; Pawlak, C.C. 1; Bell, T.W. 2

1- University of California, Los Angeles 2- University of California, Santa Barbara

Over the last five years, bull kelp populations in northern California have drastically declined in response to the 2014-2016 marine heatwave, sea star disease, and subsequently large increases in herbivorous purple urchin populations. Despite the regional kelp forest collapse, there are small remnant populations where bull kelp has shown both resilience and persistence. These kelp refugia are likely to be critical to the regional recovery of kelp populations, as they will likely serve as important sources of spores for recolonization of empty habitat once conditions improve. However, we lack comprehensive data on the locations of these refugia and the factors that enable them to persist. There has been success in using Landsat data for analyzing regional bull kelp canopy dynamics, but the relatively coarse resolution (30 m) is not sufficient for mapping small, sparse, or nearshore patches of kelp. We developed a methodology for mapping bull kelp canopy from 3 m resolution PlanetScope satellite imagery and created annual maps of bull kelp canopy in Sonoma and Mendocino counties from 2016 to present. We compared the locations of refugia to environmental factors such as bathymetry, benthic substrate, and localized oceanographic conditions (i.e. upwelling) to gain a better understanding of the drivers of bull kelp resilience and recolonization after large disturbances.

**SEAGRASSES AS POTENTIAL OCEAN ACIDIFICATION REFUGIA FOR OYSTERS** *(YOUTUBE)*

Merolla, S.A. 1*; Isaak, A. 2; Ricart, A.M. 1; Sanford, E. 1; Gaylord, B. 1; Hill, T.M. 1
Ocean acidification is a substantial threat to marine calcifiers, such as shellfish that serve important roles in ecosystem habitat formation and in aquaculture. Recent literature has suggested that marine macrophytes could provide refugia for shellfish by modifying seawater chemistry through photosynthesis, thus mitigating the effects of ocean acidification. Our study aimed to test the hypothesis that the presence of seagrass will result in higher calcification of oysters in both ambient and elevated CO$_2$ seawater conditions. The Pacific oyster *Crassostrea gigas* was incubated in laboratory chambers in the presence and absence of the seagrass *Zostera marina*. Incubations were conducted with both ambient (450 μatm) and elevated CO$_2$ seawater (1000 μatm) and ran in both light and dark periods. Rates of calcification for oysters were measured using changes in seawater total alkalinity. The presence of seagrass enhanced calcification of the oysters in both ambient and elevated CO$_2$ seawater (by 89% and 114% respectively) during the light periods, but not during the dark periods. This result suggests that seagrass photosynthetic activity can produce seawater chemistry changes that are beneficial to oyster calcification even under ocean acidification conditions. These findings enhance our understanding of how seagrasses can influence the performance of calcifying organisms in the context of future climate change, with important implications for the management of seagrass ecosystems and sustainable aquaculture.

**ASSESSING THE RESPONSE OF GROUNDWATER-FED COASTAL ECOSYSTEM TO SEA LEVEL RISE ON THE ISLAND OF HAWAII (YOUTUBE)**

Marrack, L.M.; Wiggins, C.; Most, R.; Marra, J.J.; Genz, A.; Falinski, K.; Conklin, E.

Groundwater-fed anchialine pools are tidally influenced coastal habitats that connect underground to the ocean through porous substrate. Hawaiian anchialine pools support endemic and endangered species of crustaceans, damselsflies, birds, and gastropods. Introduced fishes, destructive land use, water pollution and withdrawal, and senescence fueled by introduced vegetation destroy or degrade pools – these threats may be exacerbated by sea level rise. Predictions of future anchialine habitat location and condition were mapped for West Hawai‘i at intervals between 2018 and 2080. Flood models incorporated field surveys of over 450 anchialine pools, in-situ measurements of groundwater levels, and estimates of flood magnitude and frequency that include probabilistic projections of future sea levels in the region. Combining groundwater and ocean levels in flood frequency projections enabled us to determine where future habitats will emerge, where current habitats will be lost, and where risks such as invasive fishes may spread as waters rise. Although 80% of the 509 current pools will be lost by 2080, over 1,000 new pools are projected to form inland. As flooding increases, introduced fish will disperse into new habitat unless action is taken to restore priority pools before they become connected. Managers, planners, and coastal community members worked with designers to create a web-based decision support tool to visualize and incorporate future sea level risk to coastal ecosystems into their plans and actions.

**COMBINED EFFECTS OF MARINE HEATWAVES, MINING, FISHING, AND URBAN RUNOFFS ON KELP FORESTS CARBON CAPTURE (YOUTUBE)**

† Paz Lacavex, Andrea; Beas, Rodrigo; Lorda, Julio; Cavanaugh, Kyle; Bell, Tom

1- University of California Santa Cruz 2- Universidad Autónoma de Baja California 3- University of California Los Angeles 4- University of California Santa Barbara
Kelp forests are one of the most productive coastal ecosystems in the world. The brown algae *Macrocystis pyrifera* provides a great diversity of ecosystem goods and services to humans. However, kelp forests are thought to be disappearing worldwide and its potential for blue carbon, due to extreme marine heatwaves Kelp forests are not only affected by environmental variability but also by several other anthropogenic agents of change such as fishing, coastal development, and run-offs. The interactions between climate variability and direct human disturbances make some kelp forests thrive while others disappear. This study aims to explore how the integration of different sources of information can potentially help us understand environmental and direct anthropogenic impacts to inform adaptive management actions. Specifically, we evaluated the historical dynamics of kelp canopy biomass using remote sensing tools and estimated biomass and persistence response related to different sites affected by a combination of natural variation and anthropogenic impacts. Three sites with kelp beds were compared in Bahía Todos Santos: Sauzal, Punta Banda, and Punta China. Sites were characterized according to their distributions, surface, kelp biomass and persistence, species richness, and carbon capture capacity. We found a variety of responses to MHW among the three sites likely attributed to geomorphology, environmental regime, and anthropogenic impacts. Through this exercise, we found data gaps and generated management recommendations and actions to sustain coastal ecosystem services.

**COAST-WIDE EVIDENCE OF LOW PH AMELIORATION BY SEAGRASS ECOSYSTEMS (YOUTUBE)**

Aurora M Ricart¹; Melissa Ward ²; Tessa M Hill ³; Eric Sandford ⁴; Kristy J Kroeiker ⁵; Yuichiro Takeshita ⁶; Sarah Merolla ²; Priya Shukla ²; Aaron Ninokawa ²; Kristen Elsmore ²; Brian Gaylord ⁴

¹- Bodega Marine Laboratory, University of California, Davis & Bigelow Laboratory for Ocean Sciences (present address) ²- Bodega Marine Laboratory, University of California, Davis ³- Department of Earth and Planetary Sciences & Bodega Marine Laboratory, University of California, Davis ⁴- Department of Evolution and Ecology & Bodega Marine Laboratory, University of California, Davis ⁵- University of California, Santa Cruz ⁶- Monterey Bay Aquarium Research Institute

The global threat of ocean acidification has spurred interest into the capacity for seagrass ecosystems to locally increase seawater pH through photosynthetic uptake of CO₂. However, limitations on the scope of prior studies, and the complexity of underlying drivers, have created uncertainty regarding the generality of potential seagrass-pH benefits. Here we present results of a six-year study encompassing seven seagrass meadows along the U.S. west coast that explores the capacity of temperate seagrass ecosystems to elevate seawater pH. We find higher average pH within seagrass meadows compared to non-vegetated areas (mean increase of 0.07 ± 0.002 SE), and sustained elevated pH, leading to events of high pH within seagrass meadows longer than expected by day-night light cycles alone (> 0.1 unit persisting up to 21 days). The greatest pH elevations occur in spring and summer during the seagrass growth season, with a tendency for more pronounced effects in higher latitude meadows. These results confirm that seagrass meadows can locally alleviate low pH conditions at physiologically and ecologically relevant timescales, with important implications for the conservation and management of coastal ecosystems.

**BENTHIC BIOGEOCHEMICAL VARIABILITY IN TEMPERATE ROCKY REEFS: COMMUNITY CONTRIBUTIONS DEPEND ON PHYSICS (YOUTUBE)**

† Panos, D.A.∗; Nickols, K.J.

*California State University, Northridge*

Kelp forest benthic zones have reduced water motion from kelps’ structural biomass and friction with the seafloor, potentially enabling organisms to contribute to water chemistry. Understory community composition is variable and shifts to alternative states such as barrens may have
biogeochemical consequences with producer loss. We quantified biogeochemical conditions associated with different understory communities to assess community contributions to variability. Dissolved oxygen (DO), temperature, and relative water movement were measured directly in and 1 meter above bottom in 3 community types in coastal Monterey Bay (Central California) and 4 community types along Palos Verdes peninsula (Southern California) in addition to measurements of DO and temperature at the surface and mid-water column at a mooring at each site. Community type influenced relative water movement in Monterey Bay but not along Palos Verdes where water motion was greater. DO was similar among community types at both Monterey and Palos Verdes. Biogeochemical patterns between regions differed, associated with oceanographic processes. In Monterey Bay, a stratified water column experiencing upwelling likely swamped out biological contributions to benthic biogeochemistry. At Palos Verdes biological contributions to biogeochemistry from giant kelp was detected throughout the water column, which was a well-mixed water column. This study shows that physical conditions of a system, such as upwelling and mixing, determine the degree to which a biological signal may manifest in benthic biogeochemistry.

DISEASE DRIVEN CHANGES IN THE REALIZED NICHE OF AN APEX PREDATOR*

1- Oregon State University 2- The Nature Conservancy 3- University of British Columbia, Hakai Institute 4- Monterey Bay National Marine Sanctuary, NOAA 5- Universidad Autónoma de Baja California 6- Simon Fraser University 7- California Department of Fish and Wildlife, Bodega Marine Lab at UC Davis

The Sunflower Star, Pycnopodia helianthoides, was catastrophically affected by the massive outbreak of sea star wasting syndrome (SSWS) in the mid-2010s. While Pycnopodia populations were drastically reduced across their entire range, some populations were impacted less by the disease. Previous studies suggest that local environmental conditions, specifically temperature, influenced the severity of the outbreak. Where are the remaining populations of Pycnopodia and what habitats are associated with persistence of Pycnopodia populations post-outbreak? To answer these questions, we combined 30+ datasets spanning Pycnopodia's range with species distribution modelling to characterize changes in the species' realized niche before and after the outbreak of SSWS. Early results indicate that prior to the outbreak, Pycnopodia's realized niche was most strongly characterized by depths of less than 200m, high salinity water, and a range of water temperatures between 6-14 °C. After the outbreak, Pycnopodia's niche narrowed and shifted towards cooler (5-11°C) and shallower (<100m) populations. Salinity became a weaker predictor of their realized niche and conversely the percent contribution of temperature in predicting the realized niche jumped from 32% to 60%. Four to seven years since these outbreaks first emerged, the realized niche of Pycnopodia is now more strongly characterized by temperature, which could reflect interactions between the disease-causing agent and temperature. Whether these changes are more permanent or dynamic remains to be seen.

Effects of an epiphytic bryozoan on growth and primary production of the giant kelp
*Macrocystis pyrifera*
† Cohn, B.C.; Nickols, K.J.

California State University, Northridge

Giant kelps are among the most productive marine macrophytes and can significantly alter surface water chemistry through photosynthesis with the potential to serve as refugia from rising pH and hypoxia. Along the California coast, Macrocystis pyrifera is the dominant kelp species and is
commonly encrusted by the bryozoan Membranipora spp., which forms a crustose, opaque layer on kelp thalli. Reduction of incident light by this layer may hinder primary production with potential implications for kelp growth and surface water chemistry within kelp forests. The effects of bryozoan encrustation on growth and primary production were investigated by measuring blade growth and dissolved oxygen production in situ and in the laboratory from June–August, 2019 in Monterey and Palos Verdes, CA. Blades in the surface canopy were measured weekly using a hole-punch method and photosynthesis/respiration trials were conducted on blades of varying levels of bryozoan encrustation inside sealed respiration chambers. Growth surveys revealed that bryozoans likely did not affect blade growth, but encrusted blades showed a slightly greater decline in blade length. In both field and lab experiments, non-encrusted blades had O₂ production rates 2–3 times greater than encrusted blades, while O₂ consumption rates were 1.1–1.5 times greater for encrusted blades. These results suggest that bryozoan encrustation can significantly decrease primary productivity of M. pyrifera which may have implications for kelp’s ability to alter surface water chemistry and act as refugia from effects of climate.

Session 15: Special Session: Towards equitable collaboration in community-based research

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

LEARNING FROM HAWAIIAN CULTURE TO IMPROVE MARINE CONSERVATION RESEARCH

Puniwai, N.¹; Early Capistrán, M.M. ²

1- University of Hawaii at Manoa 2- Universidad Nacional Autónoma de México

Marine conservation scientists work in a fluid, interconnected context: the ocean. Our research often occurs across geographical, geopolitical, or socio-cultural boundaries. Marine conservation scientists must be aware of the social and ecological contexts in which we work, and the multiple sources of cultural and pragmatic importance that the sea and the organisms we study have for the communities where we conduct our research, especially when conservation research may translate into material outcomes for local people. The Hawaiian concept of *pono* can provide valuable lessons for engaging in marine conservation research across social and ecological contexts. *Pono* references the search for righteousness and prosperity, the action of doing good, and the state of wellness achieved. *Pono* is a holistic concept which can help guide ethical marine conservation research. A *pono* vision moves us beyond the defense of right conduct that structures our conversations around ethics and into a state of responsibility to ensure that our motivation in seeking *pono* is for the prosperity of all communities. Through an intercultural dialogue, we discuss two foundational ethical principles that can guide *pono* science: respect for different ways of knowing and valuing the ocean and developing a new relationship to research and knowledge. We aim to initiate a conversation within our discipline of how to better acknowledge, approach, and engage the ethical issues we face.

GINA K’AADANG.NGA GII UU TLL K’ANGUUDANG—SEEKING WISE COUNSEL: DRAWING ON MULTIPLE KNOWLEDGE SYSTEMS ON HAIDA GWAI, BC

Lee, L.C.¹; Jones, R ²; Okamoto, D.K. ³; McNeill, D. ⁴; Winbourne, J. ⁵; Bellis, V. ⁴

1- Gwaii Haanas Parks Canada 2- Council of the Haida Nation, Marine Planning Program 3- Florida State University 4- Council of the Haida Nation, Haida Fisheries Program 5- Independent ethnobiologist
Seeking wise counsel is one of six ethics and values in the Haida Gwaii Marine Use Plan and Gwaii Haanas Gina 'Waaddluxan KilGuhlGa (Talking about Everything) Land-Sea-People Management Plan, recognizing the importance of drawing on multiple and diverse knowledge systems to address conservation and management issues. The Haida Nation is a co-management partner in development and implementation of both plans that seek to ensure ecosystem-based management and sustainable use that also benefits Haida Gwaii communities. This principle facilitates community-based research that is respectful of Haida culture, values and laws, while also considering new ideas, traditional knowledge and scientific information. Through stories of how we have worked together to document and use Haida traditional and western scientific knowledge in planning, management and research, we will highlight what has worked for us and what we have learned over the years. Focal initiatives include the Haida Marine Traditional Knowledge Study; Chiixuu Tll iiñasdll – Nurturing Seafood to Grow kelp restoration project in Gwaii Haanas; Haida Gwaii iinang herring rebuilding; Haida Gwaii Marine Stewardship Group; and Xaayda Gwaay.yaay Kuugaay Gwii Sdíihl’l’xa – The Sea Otters Us Return project.

**Between desert and sea, Indigenous and scientifics tribes (YOUTUBE)**
† Catherine Ramos García*

*Universidad del Cauca*

Latour and Woolgar (1985) stated that indigenous tribes have been broadly studied, in contrast with scientific tribes which are rarely studied. In this talk, we study the interaction between those two tribes. Every year, dozens of researchers of various nationalities go to work to the Comcaac territory in Sonora, Mexico. The people of the communities participate in some of those research projects. The primary focus of research conducted in Comcaac territory is on Comcaac interaction with nature and the knowledge derived from this interaction. In this exchange, the life stories of the researchers and the people of the community with whom they work are interwoven. Interchanges of knowledge, money and power are established, networks are born, and traditional and scientific knowledge systems circulate. The Comcaac or Seris are an indigenous community which has built close relations with the beings in the sea and the desert. Whales, sea lions, dolphins, turtles, snails, lynxes and bighorn sheep are some of the beings of the sea and the desert that play the main role in the stories through which the relationships between researchers and members of the community are traced. It is equally important to observe how networks are woven. This includes networks between researchers, between researchers and the community, among community members who participate in researchers, and between the different beings that are involved in these dynamic relationships. These relationships depend on social, circumstances of the community, as well as on natural cycles.

**INTEGRATING TEK IN FISHERIES AND ECOLOGY PROJECTS BY FOSTERING TRUST WITH SMALL-SCALE FISHING COMMUNITIES**
Nicole Corpuz*

*Amigos Marinos*

Comprising roughly 90% of the world’s capture fisheries and 50% of global catch, small-scale fisheries are made up of local fishermen who use traditional fishing methods to provide seafood that is consumed in their household or local community. As fishery stocks continue to decline, government agencies, non-governmental organizations and research institutions are continuously working toward rebuilding global fisheries and improving the health of marine ecosystems. Since robust fisheries are linked to healthy ecosystems, the integration of Traditional Ecological Knowledge (TEK) is essential in the development of fishery rebuilding and ecology projects given
that traditional fishermen possess knowledge of the ecological systems of the marine environment that has been passed down through multiple generations. Throughout small scale fishing communities in Baja California Sur (BCS), Mexico, fishermen often express mistrust toward scientists. It is common for fishermen to believe that scientists discount their knowledge of the sea, while scientists mistrust the data that fishermen report, thus making it difficult to develop projects that integrate TEK. Reflecting on feedback from fishermen and over three years experience living among and working closely with small-scale fishermen in BCS, I will discuss ways to foster communication with traditional fishing communities. Traditional fishermen often struggle to explain their knowledge verbally, thus demonstrating the importance of spending time with fishermen in the field which is made possible through fostering trust.

**TECHNOLOGY USE, INFORMATION SHARING, AND ACCESS TO CLIMATE CHANGE KNOWLEDGE IN A SMALL-SCALE FISHERY OF BAJA CALIFORNIA (YOUTUBE)**

† Mansfield, E.J.¹; Gastelum, E. ²; Paz-Lacavex, A. ³; Bracamontes, M.A. ⁴; Micheli, F. ¹

1- Hopkins Marine Station of Stanford University 2- Comunidad y Biodiversidad A.C. 3- University of California - Santa Cruz 4- SCPP Cooperativa Ensenada

Studies show that information sharing can have an effect on fisher’s decision-making and help increase adaptive capacity with changes in the system. With increased access to the Internet and the development of social media, information sharing has begun to expand beyond the customary method of face-to-face learning through formal and informal networks. The aim of this study is to understand how traditional information may be passed through non-traditional methods with the expansion of informal networks via social media. To assess this, 80 people of various roles within a small-scale fishing cooperative in Baja California were interviewed. These semi-structured interviews asked questions about social media use, information accessed and shared on social media, explanations of climate change, and specific experience with climate change. Results show that cooperative members are aware of changes to their system, however at times there was a disconnect between the observed changes and the language used to describe climate change in general. Additionally, the majority of individuals interviewed use some form of social media, however, most rely on more experiential and informal methods to learn about changes within their system. Participants expressed interest in an opportunity to access more information about climate change through more non-traditional channels, such as on social networks sites. These results suggest there is an opportunity, to expand information sharing techniques to social media and inform on subjects to focus on and methods to use.

Session 16: Special Session: Engineering resilience in kelp forest ecosystems

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

**RESTORING KELP FOREST ECOSYSTEM SERVICES MEANS MORE THAN SIMPLY RESTORING KELP: ENACTING ECOSYSTEM RESTORATION (YOUTUBE)**

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Kelp forest ecosystem services are particularly vulnerable to climate stressors. In northern California, the collapse of the previously resilient bull kelp *Nereocystis luetkeana* forest occurred suddenly, at the start of the Marine Heat Wave (2014-16), and led to the loss of economically important fisheries and a suite of other services. Using a 20-year monitoring program, we show that purple sea urchins *Strongylocentrotus purpuratus* increased 50 fold and now dominate the system. Further, we show that sunflower stars *Pycnopodia helianthoides* are now locally extinct and red
abalone *Haliotis rufescens* experienced mass mortalities. Sea urchin removals are currently underway in small coves to support kelp restoration. It is still unknown however, if sea urchin removal alone will be enough for kelps to regrow or if active spore provisioning is needed. Meanwhile, many other components of the community will need to be rebuilt to restore function. Sunflower star restoration will need to determine if captive bred juvenile stars can survive disease in the wild. Abalone population enhancement strategies will need to create robust aggregations that account for metapopulation dynamics. Red algae communities will need to recover from overgrazing. Many of these critical ecosystem functions may not recover without climate smart restoration actions such as oceanographic analyses of recovery sites, positive species interactions/feedbacks and heat resilient genotypes. Climate driven kelp forest ecosystem collapse poses significant challenges that will require ecosystem restoration.

**GLOBAL KELP FOREST RESTORATION: PAST LESSONS, CURRENT STATUS, AND FUTURE GOALS** *(YOUTUBE)*

† Eger, A.M. 1*; Marzinelli, E.M. 2; Lynn, L. 3; Christie, H. 4; Fagerli, C. W. 4; Seokwoo, K. 5; Kim, J.H. 5; Gonzalez, A. P. 6; Fujita, D. 7; McHugh, T. 8; Tatsumi, M. 9; Steinberg, P. 1; Verges, A. 1

1- University of New South Wales 2- University of Sydney 3- Parks Canada 4- Norwegian Institute of Water Resources 5- Sungkyunkwan University 6- Universidad de Chile 7- Tokyo University of Marine Science and Technology 8- Reef Check California 9- University of Tasmania

Kelp ecosystem restoration works to compensate for declines of global underwater forests. The practice first started in the 1930s in Japan, 1960s in California, and since then, has spread across the globe. Restoration efforts, however, have been largely disconnected, with methodologies trialled by different actors in different countries. We work to bridge this gap and have created the world’s first global kelp restoration database. From this compilation, we synthesize the results of hundreds of restoration projects spanning 1957 to 2020, across 16 countries, 5 languages, and from multiple sectors of society. Our results show that kelp restoration projects are increasing in frequency, have employed 12 different main methodologies, and targeted 17 different kelp genera. Of these projects, the majority have been conducted by academics, 80% have been conducted at sizes of less than 1 hectare, and most projects are conducted over time spans of less than 2 years. We also show that projects are most successful when they are located near existing healthy kelp forest and that disturbance events such as urchin invasions are regular causes of project failure. These results are compiled in a living database which serves as a platform for recording future restoration projects, re-analyzing the data, and providing updated results based on the new information. In this way, our work establishes the groundwork to provide adaptive and relevant recommendations on best practices for kelp restoration projects today and into the future.

**A TRANSPLANTATION METHOD FOR RESTORATION OF ECKLONIA RADIATA KELP BEDS** *(YOUTUBE)*

† Graham, T.D.J. 1*; Morris, R.L. 1; Strain, E.M.A. 2; Swearer, S.E. 1

1- National Centre for Coasts and Climate (NCCC), School of BioSciences, University of Melbourne, Parkville, VIC. 3010, Australia 2- National Centre for Coasts and Climate (NCCC), School of BioSciences, University of Melbourne. Institute for Marine and Antarctic Science (IMAS), University of Tasmania, Hobart, TAS. 7000, Australia

Kelp beds are a defining feature of temperate reefs worldwide, playing a fundamental role as ecosystem engineers and primary producers. Overgrazing by the native sea urchin *Heliocidaris erythrogramma* has driven a phase shift away from kelp beds of *Ecklonia radiata* across much of Port Phillip Bay, Victoria. Here we present the results of a transplant experiment, which took
juvenile *E. radiata* from a source reef and attached them to basalt tiles with silicon tubing. We monitored the development and survival of individual *E. radiata* to investigate the drivers of loss during transplantation, including disturbance (control vs disturbance control), receiving environment (kelp canopy vs no canopy), and translocation site (within vs between reefs). We also investigated the role of holdfast reattachment and developmental stage on kelp survival. 69% of the kelp transplants survived over the 17 weeks, with no increased loss resulting from transplantation to a reef 41 km away. Our results indicate that with initial localized culling of urchins at the translocation site, transplants can survive despite high urchin densities. Furthermore, the provision of a canopy is not necessary and may result in adverse impacts on survival and development of juvenile transplants presumably through shading. Individuals at the collection location (controls) were unlikely to survive to maturity suggesting their removal for transplanting is likely to have minimal impact on the kelp population of the donor reef. The methods used could be feasibly upscaled for rehabilitating or restoring kelp beds.

**ANALYZING ALTERNATE RESTORATION STRATEGIES IN CALIFORNIA BULL KELP SYSTEMS**

† Arroyo-Esquivel, J.¹; Baskett, M. ²; McPherson, M. ³; Hastings, A. ²

1- Department of Mathematics, UC Davis 2- Department of Environmental Science and Policy, UC Davis 3- Department of Ocean Sciences, UC Santa Cruz

Recent increases in global marine temperatures have been associated with declines in kelp populations worldwide. Subsequent restoration efforts focus on urchin removal given the anticipated role of urchin grazing in impeding kelp recovery. For example, urchin removal is the current restoration focus in the northern coast of California, where a combination of an intense marine heatwave, local extinction of the sunflower sea stars (primary urchin predators), and a surge of purple urchin populations has caused a 90% decline in bull kelp coverage and 60-fold increase in urchins. Newly developing methods in kelp population enhancement through outplanting and re-seeding raise questions of their relative efficacy compared to urchin removal and whether kelp enhancement and urchin removal might be complementary or redundant. He we develop a dynamical model of kelp-urchin interactions to analyze the relative efficacy of alternate restoration approaches as it depends on grazing feedbacks. In a global sensitivity analysis of the model, the factors with the greatest influence over the rate of spread are the urchin grazing rate and the influence of kelp density on urchin grazing, as might occur through a behavioral feedback where urchin starvation intensifies grazing. In the model best fit to data, after initial urchin removal below a threshold level, kelp outplanting or seeding each outweigh continued urchin removal in increasing kelp spread rate, and combined strategies further enhance the recovery rate.

**TOWARD FULL LIFE CYCLE REARING OF THE ENDANGERED SUNFLOWER STAR, PYCNOPODIA HELIANTHOIDES**

Hodin, J.; Pearson-Lund, A.; Anteau, F.P.; Kitaeff, P.; Guenther, R.J.; Cefalu, S.

*University of Washington- Friday Harbor Labs*

In the past decade, the waters off N California experienced three coincident ecological shifts: a startling decline in bull kelp (*Nereocystis luetkeana*), an explosion in populations of the kelp-eating purple urchin, *Strongylocentrotus purpuratus*, and an unprecedented syndrome known as seastar wasting disease that seemingly impacted every NE Pacific asteroid species. In particular, the sunflower star, *Pycnopodia helianthoides*, may now be extinct or nearly extinct in California. This key generalist predator and the largest seastar in the world is known to cue in on and consume purple urchins. It is thus possible that the kelp declines may be driven in part by predatory release
on purple urchins following the sunflower star disappearance. In order to investigate the ecological function of *P. helianthoides* in the kelp forest ecosystem, and possibly foment its return to the wild, we have initiated a captive rearing program at Friday Harbor Labs in the Salish Sea, where sunflower stars persist at reduced numbers. In the past 18 mo we have established a breeding colony of stars, spawned them, and reared their embryos and larvae through settlement to early juvenile stages. Recently, we have succeeded in rearing juveniles and continue to culture the surviving offspring, the largest of which is now over 2 cm in diameter with 9 arms. Here, we will describe our findings as well as forecast our plans with rearing a new batch of larvae and juveniles this year, and testing larval responses to a range of temperature conditions and the predatory behavior of the resultant juveniles.

**THE NEW NORMAL FOR KELP FORESTS AT ISLA TODOS SANTOS**

†Rodríguez-Bravo, L.M.†; Beas-Luna, R.; Lorda, J.; Malpica-Cruz, L.; Sandoval-Gil, J.

*Universidad Autónoma de Baja California*

Anthropogenic stressors are heavily influencing coastal ecosystems. Human activity has, among other effects, increased global temperatures, altered climate patterns, and introduced numerous non-indigenous species to new ecosystems. Canopy-forming macroalgae provide the majority of habitat structure in temperate kelp forest ecosystems, but competing invasive algae, especially under the effects of climate change, may displace them, resulting in dramatic effects on ecosystem structure. Todos Santos Islands (TSI), in Baja California, is one of few sites in the Pacific Northwest outside of marinas hosting three high-profile invasive macroalgal species concurrently: *Sargassum muticum*, present at least since the 80s, has been joined in the last two decades by *Sargassum horneri* and *Undaria pinnatifida*. We surveyed two sites inside and outside a historic *Macrocrystis pyrifera* kelp forest and described the macroalgal community structure and spatio-temporal dynamics. Our results reveal these invasive algae are well established, abundant, and coexisting with *M. pyrifera*. However, this coexistence in space and time can be easily threatened by the forecasted future extreme warming events. This study showcases a macroalgal species assemblage that resulted from the combined effects of climate change and species introduction, highlighting the need to consider these kinds of communities when evaluating what ecosystem resilience means, and what the goals should be for restoration efforts in these systems.

**COMMUNITY GENOMICS OF KELP FORESTS AND GENOMIC RESCUE OF SUNFLOWER SEA STARS**

Dawson M.N†; Schiebelhut, L.M. †; Bay, R.A. ‡; DeBiasse, M.B. †

1- *University of California, Merced* 2- *University of California, Davis*

The 2013 outbreak of sea star wasting disease (SSWD) and emergence of a warm ‘blob’ in the northeastern Pacific devastated populations of several species of sea stars and associated ecosystems. The hardest hit asteriid was the sunflower sea star (*Pycnopodia helianthoides*)—a predator of urchins—which was all but eradicated (i.e. 80–100% mortality) from all but the northern-most reaches (Alaska) of its > 3000 km range. Associated ecological consequences were devastating: explosion of urchin populations (311% increase), loss of kelp forests (30% decline in densities), and as yet no sign of rebound. We are coupling two perspectives — community-level and genic — to discover the ecosystem consequences of these environmental stressors and to explore the potential for genomic recovery. From the community perspective, as part of the California Conservation Genomics Project, we are using genomic tools to explore coupled demographic and functional shifts in kelp forest ecosystems through time and across space. From the genic perspective, in partnership with Revive & Restore, we are using use genomic tools to identify
variation that was lost during the sunflower sea star die-off, that which appears adaptive, and that which may confer resilience to disease and heat (and other stressors). Insight generated from each perspective will complement diverse other efforts and help equip managers with more of the essential information needed to facilitate recovery and resilience of sea star populations and kelp forest ecosystems.

ALONGSHORE CURRENT MODIFICATION BY GIANT KELP, MACROCYSTIS PYRIFERA (YOUTUBE)
† Elsmore, K.E.1*; Nickols, K.J. 2; Ford, T. 3; Gaylord, B. 4

1- Bodega Marine Laboratory, University of California, Davis 2- Department of Biology, California State University, Northridge 3- Coastal Research Institute, Loyola Marymount University 4- Bodega Marine Laboratory, Department of Evolution and Ecology, University of California, Davis

Macrocystis pyrifera forests create biogenic habitat spanning the entire water column, which consequently imposes drag on nearshore flows. The alteration of such flows has implications for physical, chemical, and ecological processes across multiple spatial scales. At the forest-wide scale, M. pyrifera has been shown to dramatically decrease alongshore current velocities and, to a lesser degree, cross-shore current velocities. Although patterns of damped flows observed in previous investigations are clear, in situ efforts have been limited to comparisons among a few focal forests, with measurements representing flow conditions within a single forest “state” (e.g. dictated by the season). Here we quantify the relationship of current speeds among stations outside and within a temperate rocky reef that twice underwent a transition from a barren state to one in which a thick surface canopy is present. Results from this work suggest there is a stipe density threshold at which much of the damping of alongshore depth-averaged velocities occurs. Importantly, this work suggests that relatively small, thin forests can exhibit considerable damping of alongshore currents. Additionally, presence of an emerging forest’s subsurface canopy and its subsequent increase in height created a rapidly changing profile of reduced horizontal shear across the vertical plane. Such a pattern highlights the forest’s capacity to differentially modify flows in a previously undocumented way.

DO GRAZERS MITIGATE OR EXACERBATE THE IMPACTS OF CLIMATE-INDUCED BRYOZOAN OUTBREAKS ON KELP? (YOUTUBE)
† Fraser, M.1*; Denley, D. 1; Frid, A. 2; Michael, V. 2; Salomon, A. 1

1- Simon Fraser University 2- Central Coast Indigenous Resource Alliance

Rising ocean temperatures associated with climate change have been shown to increase the growth and settlement of a kelp epiphyte, the bryozoan Membranipora, and simultaneously reduce kelp resilience. What remains unclear is the degree to which natural defences may mediate these negative effects on kelp. Here, we ask if the dominant grazers of the kelp canopy have the capacity to mitigate or exacerbate the impacts of bryozoan outbreaks through potential shifts in grazing behaviour and rates as a function of bryozoan encrustation and temperature. We caged Macrocystis blades with varying levels of bryozoan cover with and without grazers present in the field across a natural temperature gradient in Barkley Sound, BC. This study reveals the cumulative impacts of temperature and bryozoan encrustation on grazing rates and net change in kelp blade biomass, as well as sheds light on how bryozoan cover impacts grazers’ rate of consumption. This research provides insights into the regulating role of grazers in kelp forests and contributes to our understanding of how impacts of climate change on species interactions affect the resilience of communities of co-evolved species. Moreover, this study documents the potential impacts and ecosystem-level responses associated with climate change and bryozoan outbreaks, key considerations for coastal communities across temperature latitudes that rely on kelp forests for
food, livelihoods, and are considered culturally and economically important, particularly among coastal First Nations communities.

**MISALIGNMENT OF THE STARS: DRAMATIC GLOBAL DECLINES OF THE SUNFLOWER SEA STAR PYCNOPODIA HELIANTHOIDES** *(YOUTUBE)*
Gravem, S.A.1; Heady, W.2; Saccomanno, V.2; Alvstad, K.F.1; Gehman, A.3; Frierson, T.4; Hamilton, S.A.1

1 Oregon State University 2 The Nature Conservancy 3 Hakai Institute 4 Washington Dept of Fish and Wildlife

The outbreak of sea star wasting syndrome (SSWS) spanned 5,000 km of the western coast of North America, affected at least a dozen species, and appears to be the largest marine epizootic on record. The hardest hit species was the sunflower sea star *Pycnopodia helianthoides*. To determine the regional variation and global magnitude of this unprecedented mortality event for *Pycnopodia*, we compiled 61,043 surveys in 31 datasets from 1956-2020 spanning Baja California to the Aleutian Islands. We estimate that the SSWS outbreak caused a 90.6% decline in the global population and killed 5.7 billion animals. The species is now extremely rare on the outer coast of the contiguous United States and Mexico (2,500 km of coastline). Severely reduced populations remain in the Salish Sea, central British Columbia, and Alaska. However, populations have not begun to recover in any region. Further, the disease is still present and warmer water increases disease severity. To highlight this issue, we have submitted an assessment to the International Union for the Conservation of Nature, and expect that *Pycnopodia* will be listed as Critically Endangered this winter. The loss of predatory *Pycnopodia* on rocky reefs is linked to dramatic increases in sea urchin populations, which can overgraze kelp. While there are multiple drivers of recent kelp declines, the lack of *Pycnopodia* and overgrazing by sea urchins are likely preventing recovery. Proactive management of *Pycnopodia* is needed, and reviving *Pycnopodia* populations may be a key tool in promoting kelp forest ecosystem health.

Session 17: Special Session: Marine heatwaves 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**AN INTRODUCTION TO THE SPECIAL TOPIC SESSION ON MARINE HEATWAVES** *(YOUTUBE)*
Hofmann, Gretchen E.*

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. The goal of this special topic session is to highlight what we have learned in the last few years about the impact of MHWs on broader-scale processes (e.g., community ecology to aquaculture), and also on different levels of biological organization (e.g., early life history stages to molecular biology). 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 thermal stress experienced by marine ecosystems and marine organisms. Overall, our session hopes to introduce graduate students to the topic of MHWs as these extreme 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 COMMUNITY SHIFTS DRIVEN BY MARINE HEATWAVES AREN’T MITIGATED BY MPAS
Freedman, R.F. 1*; Brown, J. 2; Caldow, C. 1; Caselle, J. 3

1- NOAA CINMS 2- ECOS Consulting, NOAA CINMS 3- UCSB Marine Science Institute

Efficiently quantifying ecological shifts from acute climate events is challenging, leading to a disconnect between real-time community composition and management action. Our study classified thermal affinities of kelp forest fish species using biogeographic data and expert opinion to create a simplified method to track differential responses to climatic events. We used this newly developed classification scheme to track the response of multiple fish community metrics to a marine heatwave that occurred off the US West Coast. Density and recruitment of ‘warm species’ were significantly higher during the marine heatwave (2014-2017) compared with years prior (2002-2013). ‘Cold species’ did not experience significant parallel declines. Marine Protected Areas (MPAs) did not appear to buffer these community shifts as responses were similar both inside and outside MPAs. Non-fished species were more responsive to environmental drivers compared to targeted species which means managers looking to preserve ecosystem structure in response to acute climate disturbance should utilize additional conservation strategies.

ECOLOGICAL AND EVOLUTIONARY DYNAMICS OF POLEWARD ShiftS IN GEOGRAPHIC RANGES (YOUTUBE)
Sanford, Eric*

Bodega Marine Laboratory, University of California, Davis

In association with warming temperatures, species’ geographic ranges are shifting poleward across a variety of marine and terrestrial taxa. However, the ecological and evolutionary processes that facilitate or impede geographic range expansions remain poorly understood. Moreover, we have an incomplete understanding of the roles that extreme events like marine heatwaves might play in geographic range expansions. Here, we examine how the marine heatwaves of 2014-2016 influenced the abundance and geographic distribution of coastal taxa in northern California. We report marked changes in distributions and/or abundances across a diverse suite of 67 southern species, including an unprecedented number of poleward range expansions (37). Our results indicate that these marine heatwaves provided a mechanism for rapid range expansions (mean distance +/- SE = 345.4 +/- 53.9 km) and the establishment of new marginal populations in northern regions. Whereas many of these southern species disappeared after the marine heatwaves ended, some of these northern populations have persisted, including those of the Owl Limpet, Lottia gigantea. We are investigating whether spatial sorting during dispersal and/or natural selection have led to phenotypic and genetic divergence between range-edge and southern source populations of Owl Limpets. Understanding the ecological and evolutionary processes that mediate the success of range expansions will be critical to predicting future shifts in community composition during an era of accelerating climate change.

FROM SPECIES VULNERABILITY TO COMMUNITY SHIFTS: PREDICTING IMPACTS OF MARINE HEAT WAVES (YOUTUBE)
Sorte, C.J.B.*

UC- Irvine

Heat waves can cause abrupt shifts in marine ecosystems and are increasing in frequency, intensity, and duration as the global climate changes. Compared to our ability to predict the impacts of chronic shifts in climate, predicting impacts of acute heat waves may be more within our grasp because the timescale of these extreme events more closely mirrors the timescale of ecological
experiments. Furthermore, we can document the impacts of heat waves when we have before and after data at the “right” place and time. I review experiments from my lab group that have shown that vulnerability to heat wave conditions differs in predictable ways across life cycle stages, populations, species, and species groups. In some cases, differential vulnerability is also reflected in distribution patterns. It may be possible, by integrating across scales, to anticipate the outcomes of these abrupt disturbances at the community level.

IT’S GETTIN’ HOT IN HERE: IMPACTS OF MHWS ON ROCKY INTERTIDAL ZONE TEMPERATURES AND MUSSELS (YOUTUBE)
† Chamorro, J.D.*; Hickman, R.; Hofmann, G.E.

University of California, Santa Barbara

The 2014-2016 marine heatwave (MHW) known as “the Blob” had drastic effects on communities and ecosystems along the northeastern Pacific coast. Researchers have reported shifts in species geographic ranges and catastrophic mortality events. However, most studies examining physical and biological impacts of the Blob have solely focused on offshore and subtidal communities and ecosystems. Very few have examined the impacts of this extreme climactic event on nearshore ecosystems such as the rocky intertidal zone. In this time series analysis, we used intertidal temperature and settlement data, collected by the Helmuth Lab (Northeastern University), PISCO, and MARINe, to determine the physical and biological impacts of the Blob on intertidal mussels (*Mytilus californianus*) at sites near Santa Barbara, CA. Initial findings show that daily temperature increased 1.4-2.3 °C during MHW years as compared to non-MHW years. In terms of settlement, historical data showed some seasonality in recruitment, however this seasonality was less apparent during MHW events. Although intertidal organisms are often characterized by their ability to withstand extreme temperatures, additional warming during MHWs is concerning since intertidal organisms may be living near their thermal limit at certain sites along their biogeographic distributions. Because MHWs are predicted to increase in frequency and duration, it is important that we better understand the impacts of the extreme heat events on these vulnerable ecosystems.

IF YOU CAN’T STAND THE HEAT, STAY OUT OF THE GONAD: PATERNAL HEAT STRESS DIMINISHES FERTILIZATION SUCCESS IN THE PURPLE SEA URCHIN (YOUTUBE)
† Leach, T.S.*; BuyanUrt, B.; Hofmann, G.E.

University of California, Santa Barbara

One potential mechanism of resistance to rapid changes in temperature, such as marine heatwaves (MHWs), is intergenerational plasticity. In this study, using temperatures observed during Santa Barbara MHWs, we examined the impact of paternal thermal history on offspring development and performance in the purple sea urchin, *Strongylocentrotus purpuratus*. Male urchins were acclimated to either a non-MHW (13 °C) or a MHW (20 °C) temperature for 28 days, a period that encompasses the spermatogenesis process. Sperm from individual males was then used to fertilize pooled eggs from females that were maintained at non-MHW conditions. The goal was to test the impact of paternal thermal history on both: (1) fertilization success and (2) offspring performance via larval morphometrics and thermal tolerance. Fertilization success trials were carried out for each male under different fertilization environments varying in temperature (non-MHW vs MHW) and sperm concentration. Separately, offspring resulting from each male-pooled female crossing were raised under both temperature treatments and assayed at the pluteus larval stage. For the fertilization process, paternal MHW exposure had a significant negative affect on the ability of sperm to fertilize eggs, particularly at lower sperm concentrations. As environmental stressors like those experienced during MHWs could disproportionately affect either male or female organisms, studies delving
further into both paternal and maternal effects could aid in more accurate determinations of a species' ability to withstand environmental change.

Session 18: Community Ecology 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award

EXAMINING SPATIOTEMPORAL PATTERNS IN RHODOLITH BEDS USING COLLAPSIBLE BENTHIC ISOLATION TENTS (cBITs) (YOUTUBE)
† Ambat, D.S.1; Beckley, B.A. 1; Gabara, S.S. 2; Steller, D.L. 3; Edwards, M.S. 1

1- San Diego State University 2- San Diego State University, Department of Environmental Science and Policy, University of California, Davis 3- Moss Landing Marine Laboratories

Anthropogenic disturbances can decrease ecosystem function in marine habitats. Rhodoliths, free-living coralline algae, form dense beds on the benthos and were recently described at Santa Catalina Island. Previously, we estimated the impact of mooring chain disturbance on patterns of primary productivity in these rhodolith communities by comparing gross community production in undisturbed and adjacent disturbed rhodolith beds within collapsible Benthic Isolation Tents (cBITs). In this current study, we asked if these cBITs properly captured spatiotemporal variation in rhodolith communities. We deployed cBITs in undisturbed and disturbed habitats at three sites across Santa Catalina Island during three seasons. We measured community composition within each cBIT by collecting in situ community data for algal biomass, primary cover, and invertebrate abundance. Our results indicate that rhodolith cover and macroalgal biomass are significantly higher in undisturbed, compared to disturbed, rhodolith beds. Algal biomass also significantly differs between sites, but not across sampling times. Percent cover of primary substrate types is significantly different between habitats and sites and across sampling times. Invertebrate abundance is significantly higher in undisturbed rhodolith beds compared to disturbed rhodolith beds, but there are no significant differences in invertebrate abundance between sites or across sampling times. Our results suggest that cBITs properly captured spatiotemporal variability in community composition within the undisturbed and disturbed rhodolith beds.

USING MULTIPLE TROPHIC LEVELS TO ESTIMATE LARGE SCALE PATTERNS IN δ^13C and δ^15N IN THE NORTH PACIFIC: A NOVEL ISOSCAPE APPROACH
† Arnoldi, N. S. 1; Madigan, D. J. 2; Litvin, S. Y. 3; Micheli, F. 1; Carlisle, A. B. 4

1- Stanford University 2- University of Windsor 3- Monterey Bay Aquarium Research Institute 4- University of Delaware

Stable isotope (SI) analysis of animal tissues has emerged as an important tool for examining food web dynamics and tracing animal movement in the open ocean. Using SI analysis to reconstruct animal movement and habitat use on large spatial scales requires the construction of isotopic landscapes or “isoscapes”, which consist of spatially explicit predictions of elemental isotope ratios across ecologically relevant scales for the species of interest. While stable isotope ratios of carbon and nitrogen (δ^13C and δ^15N) in algal phytoplankton has been simulated on a global scale, using these data to infer movement for high level consumers requires extrapolating baseline isoscapes over numerous trophic levels. We tested the validity of this approach by constructing novel isoscapes for carbon and nitrogen among successive trophic levels across the North Pacific Ocean using data from 100 studies published before 2020. Species specific SI ratios of fishes and invertebrates were aggregated into trophic bins and used to calculate mean SI values within Longhurst Biogeographic provinces. Our calculated trophic bin δ^13C and δ^15N values reflected modeled global algal phytoplankton isoscapes, demonstrating that baseline isotopic signatures are
consistently propagated up through regional food webs. These comparisons establish the efficacy of using baseline SI data across broad geographic scales to predict movement of higher level consumers.

**EPIFAUNAL COMMUNITY RECOVERY IN SAN FRANCISCO ESTUARY EELGRASS (ZOSTERA MARINA) BEDS AFTER EXTENDED LOW SALINITY (YOUTUBE)**

† Ayala, G.S.*; Boyer, K.E.

*Estuary and Ocean Science Center, San Francisco State University*

Severe weather events are predicted to increase in intensity and frequency in the future, and their effects on community composition and functioning in estuaries is poorly understood. The San Francisco Estuary (SFE) experienced a historically wet winter in 2017 when heavy rainfall reduced surface salinities drastically for several months, but the impact of this extended period of low salinity on organisms in the shallow subtidal region of the central bay was unknown. Eelgrass (*Zostera marina*) is an important habitat-forming species in temperate estuaries worldwide, hosting a diverse community of epifaunal invertebrates. We surveyed three SFE eelgrass beds representing different regions of the bay from 2016-2019 to capture changes in epifauna community composition from before and well after the heavy rainfall period. Following the low salinity period, all three eelgrass beds shifted in community structure while remaining distinct from each other. Importantly, this shift included disappearance of two key native species that feed on eelgrass epiphytes to the benefit of eelgrass, and these species have remained largely absent. At the same time multiple invasive invertebrates became more abundant, including one that consumes eelgrass tissues. The persistence of limited community reassembly even after several years highlights the vulnerability of eelgrass habitats to episodic events that are likely to become more common as climate changes intensify.

**IT’S THE TIME OF THE SEASON…THAT MAY SHAPE SUBTIDAL SEAWEEDS’ RESPONSE TO GLOBAL CHANGE (YOUTUBE)**

† Bell, L.E.*; Kroeker, K.J.

*University of California Santa Cruz*

In the North Pacific, subtidal seaweed communities experience significant environmental variation throughout the year due to asynchronous seasonal changes in light availability, water temperature, carbonate chemistry and nutrient supply. Marine climate change in this region will interact with this seasonality; as a result, the responses of high-latitude macroalgae to projected ocean acidification and warming are very likely to be governed by season. In order to test this theory, I used a manipulative mesocosm system in Sitka, Alaska to grow three common kelp species for one month in both winter and summer, nesting simulations of future ocean acidification and warming scenarios within the light and nutrient regimes characteristic of each season. Seasonally-specific growth rates in the lab under current temperature and pCO$_2$ regimes were comparable to measured growth in the field. End-of-century temperatures significantly reduced growth in all three species under summer scenarios, but future winter scenarios of increased temperature impacted growth in only one species. Increased pCO$_2$ did not affect growth for any species in either season. Macoralgal photophysiology, carbon and nitrogen content, carbon use strategy and chemical defenses under future global change scenarios were assessed and are currently being analyzed. Incorporating seasonal scenarios into marine global change research is critical to understanding how year-round changes to the habitat and food supply provided by macroalgal communities may influence the long-term trophic structure of these ecosystems.
COMPARING THE SHALLOW BENTHIC INVERTEBRATE RECOVERY FROM THE END-CRETACEOUS MASS EXTINCTION AT TWO U.S. GULF COAST SITES (YOUTUBE)
† Beltracchi, R.B. *; Pietsche, C.

San Jose State University

Research on ancient mass extinction events contributes understanding of modern ecosystems’ potential responses to extreme stresses. The Cretaceous-Paleogene (K-Pg) mass extinction event, 66 million year ago, is an interval of taxonomic and ecological shifts in both terrestrial and marine communities. This study tests for differences in functional ecology during the extinction recovery in two shallow marine environments on the U.S. Gulf Coastal Plain.

Samples were collected from two K-Pg boundary sites, the Darting Minnow Creek section in Brazos, Texas and the Ouachita River section in Malvern, Arkansas. Both represent shallow marine environments, but the Malvern site was closer to the coastline. Bulk samples of shallow marine invertebrates were collected from three fossiliferous horizons at Brazos and at 50 cm intervals for the 4 meters above the K/Pg at Malvern. For each sample, specimens were identified to the lowest possible taxonomic level and were assigned an ecological life-mode (feeding, motility, and position relative to the substrate). Shell volume was modeled as an ellipsoid as a proxy for body size.

Fossil preservation at each site was noticeably different, with fragmented, unaltered shell at Malvern and moldic preservation at Brazos. At both localities, both the total abundance of fossils and mean and maximum body size increased through time. The Brazos samples show little changes in ecospace occupation over time; while at Malvern, there are more patterns consistent with recovery from the disaster interval.

DID THE SEA STAR CRASH PRECIPITATE ECOLOGICAL RELEASE OF KELLET’S WHELK?
(YOUTUBE)
White, C. 1*; Liou, C. 1; Beas, R. 2; Abadía, A 2; Caselle, J. 3; Carr, M. 4; Freiwald, J. 4; Lorda, J. 2; Micheli, F. 5

1- Cal Poly 2- UABC 3- UCSB 4- UCSC 5- Stanford

Sea stars can be competitors with Kellet’s whelk (Kelletia kelletii) for common food, and predators of the whelk. Starting in 2013, sea star populations in the whelk’s range crashed due to sea star wasting disease. We tested for competitive and/or mesopredator release of Kellet’s whelk populations due to the loss of sea stars. We analyzed time series of population densities for K. kelletii and Pisaster brevispinus, P. giganteus and P. ochraceus sea stars at reef sites in central, southern, and Baja California, derived from transect surveys by PISCO, ReefCheck, and Stanford-COBI monitoring programs. To help remove confounding factors affecting whelk population change, at each site we de-trended the time series of whelk density following the sea star crash (2013-16) using the slope of the change in whelk density prior to the crash (2010-13). We then regressed the annual, post-crash sea star and de-trended whelk population densities. Using sites as replicates, we tested for a negative Pearson correlation (suggesting ecological release) and a negative slope coefficient (indicating strength of release) between whelk and sea star densities. Preliminary results indicate significant but weak ecological release of Kellet’s whelk from P. ochraceus, and perhaps P. giganteus, in southern California. We conclude that ecological release of Kellet’s whelk by the sea star crash is either limited in scope and strength, or more prevalent and possibly stronger than detectable by our experimental design. This research can help inform efforts for restoring sea star populations.
Investigating the Potential for Evolutionary-Rescue by Association in a Model Cnidarian-Dinoflagellate Symbiosis (YouTube)
† Moffat, J.M.; terHorst, C.P.

California State University, Northridge

Evolutionary rescue occurs when individuals resistant to environmental stress survive and reproduce in a declining population, resulting in trait evolution on ecologically-relevant time scales. Evolutionary rescue by association could occur if a mutualist is able to rapidly evolve and rescue their host from environmental pressures, even in the absence of host evolution. We investigated the potential for evolutionary rescue by association using a model cnidarian-dinoflagellate mutualism: the upside-down sea jelly Cassiopea xamachana and its microalgal endosymbiont, Symbiodinium microadriaticum. We measured symbiont strain response to temperature in culture and then introduced these strains to polyps to determine if symbiont trait differences affected host fitness response to temperature. We quantified several components of host fitness, including survival, timing of developmental stages, and asexual reproduction. Symbiont strains varied in their response to temperature in culture, suggesting that the standing genetic variation required for natural selection to occur exists and could result in rapid evolution in response to warming oceans. Several of the host fitness measurements varied in response to an interaction between temperature and symbiont strain. This significant interaction suggests the potential for selection on the symbionts to affect host fitness, and therefore the possibility of evolutionary rescue by association. This eco-evolutionary interaction may be a critical component of understanding species resilience in an increasingly stressful environment.

Environmental Influence on Spatial and Temporal Variability in Rocky Intertidal Successional Trajectories (YouTube)
Anderson, R.K.; Bachhuber, S.M.; Poirson, B.N.; Menge, B.A.

Department of Integrative Biology, Oregon State University

Rocky intertidal community structure is heavily influenced by successional processes following repeated disturbance events. Successional trajectories are influenced by the structure of the surrounding community and environmental conditions including temperature and nutrient availability. We ask how upwelling strength, water and air temperature are associated with spatial and temporal variation in successional trajectories. To simulate disturbance, we scraped 5 15x15 cm plots clear of organisms at 4 sites spanning from Oregon to central California and assessed species abundance every 3 months for 1.5 years. We used NOAA daily Optimum Interpolation Sea Surface Temperature (OISST), in-situ loggers, and 2 upwelling indices (CUTI, an estimate of vertical transport, and BEUTI, an estimate of upwelling-associated coastal N flux) to assess environmental conditions at each site and time point. We investigated the relationship between community structure and environmental conditions at each site using non-metric multidimensional scaling (NMDS) and PERMANOVA. As expected, plot community structure varied in both time and space, diverging at the site level over time. At the final time point, sites to the north had higher abundance of invertebrates, while southern sites were algae-dominated. Preliminary analysis indicates that variability in OISST and BEUTI drove about 10% of variation in community structure, while CUTI did not drive any variation. Research into spatiotemporal variability in community response to disturbance is critical in today’s rapidly changing ocean.

Session 19: Conservation and Restoration 1
* indicates presenting author, † indicates eligibility for Best Student Paper Award
MODELING HABITAT COVARIATES FOR ATLANTIC OYSTER DRILLS IN RICHARDSON BAY, CALIFORNIA (YOUTUBE)
Blumenthal, J.G. 1*; Hines, E.M. 2; Nanus, L. 3; Chang, A.L. 4; Zabin, C.J. 4; Cheng, B.S. 5

1- Smithsonian Environmental Research Center; San Francisco State University 2- Estuary and Ocean Science Center at San Francisco State University 3- San Francisco State University 4- Smithsonian Environmental Research Center 5- University of Massachusetts, Amherst; Smithsonian Environmental Research Center

The Atlantic oyster drill Urosalpinx cinerea is an introduced muricid whelk in San Francisco Bay that has posed significant challenges to Olympia oyster restoration projects on the United States West Coast. Atlantic oyster drills have a patchy spatial pattern of presence and absence in San Francisco Bay and occur in a range of abundances where they are present. This project incorporated substrate composition, elevation, water temperature, salinity, inundation, and drill abundance data collected from summer 2017 to summer 2018 at eight sites in Richardson Bay, an embayment of San Francisco Bay, to model the significance of key abiotic habitat factors. Using generalized linear mixed effects models with logistic and negative binomial distributions, we determined that amount of coarse substrate cover and elevation above mean lower low water were significant environmental factors positively associated with drill abundance. The availability of coarse substrate at a site, however, does not predict drill presence. Our hope is that these model results will contribute to appropriate site selection of Olympia oyster restoration projects.

MOLECULAR APPROACHES FOR EELGRASS CONSERVATION (YOUTUBE)
† Briones Ortiz, B.A.1*; Ruesink, J.L. 2; Naish, K.A. 1

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

Global declines and mixed success in restoration of seagrasses warrant the exploration of a variety of research approaches to improve conservation efforts for these marine angiosperms. Eelgrass, Zostera marina, is a key ecosystem engineer in West Coast estuarine habitats, displaying a wide range of phenotypic diversity throughout its range. Foundational research has identified the existence of distinctive ecotypes across the landscape, which suggests genetic structure and possibly, local adaptation. Specifically, annual and perennial populations mainly allocate resources to sexual and vegetative reproduction, respectively. Investigating the evidence for structure and local adaptation is essential for effective management and restoration. This project aims to link population genetic structure patterns and the genetic basis of trait variation in native eelgrass to improve coastal conservation efforts. Here, next-generation sequencing will be used for extensive genotyping to investigate the genetic connectivity among 16 eelgrass populations throughout five major oceanographic regions in Washington State. Reciprocal transplants in the field will be used to explore the extent of phenotypic plasticity and local adaptation of key traits. In doing so, we aim to address the decades-long debate about the differential allocation of resources to reproductive effort in Z. marina, and whether this allocation is adaptive. These outcomes will inform management to improve restoration success and maintain the resilience of eelgrass meadows in light of environmental change.

SEASKETCH - EXPLORING DEEP SEA CORL & SPONGE COMMUNITIES (YOUTUBE)
Cajandig, Mari.T*

NOAA Channel Islands National Marine Sanctuary
Geographic Information Systems (GIS) and Marine Spatial Planning (MSP) go hand in hand when preparing for the future of our marine ecosystems. But, how do we begin to prepare the next generations of marine scientists and leaders to visualize such spatial information, and make informed decisions regarding ocean use and resource conservation? To tackle this question, the National Oceanic and Atmospheric Administration’s Office of National Marine Sanctuaries has teamed up with the UC Santa Barbara’s SeaSketch team to build a web-based, interactive map portal that will grant high school students a hands-on experience with addressing the problems that real world scientists face today. This SeaSketch portal will introduce high school students to the interconnection between today’s mapping technologies and the conservation of some of the world’s most vulnerable underwater resources, deep-sea coral and sponge communities. Students will be challenged to utilize real observation records from the Deep Sea Coral Research and Technology Program’s national database, along with other relevant data layers (i.e. human use data, habitat/environmental information, etc.), to create their own spatially-explicit solutions in response to specific prompts in the accompanying lesson plans. Students will be asked to develop and justify various spatial plans for exploring and protecting deep-sea coral and sponge communities along the West Coast.

**CANNIBALISM IN CAPTIVE PYCNOPODIA HELIANTHOIDES JUVENILES** *(YOUTUBE)*
Cefalu, S.N.*; Anteau, F.P.; Pearson-Lund, A.; Kitaeff, P.; Guenther, R.J.; Hodin, J.

*University of Washington*

Seastars are benthic predators that commonly exhibit unspecialized diets and opportunistic feeding patterns. Multiple asteroid genera have recorded incidents of cannibalistic behaviors, with some data suggesting that captivity exacerbates cannibalistic tendencies. In the case of sunflower seastars, *Pycnopodia helianthoides*, adults in the field have documented diets of marine mollusks, crustaceans, and various echinoderms. However, insufficient data are available regarding the diets of juvenile *P. helianthoides* or regarding the risks of cannibalism while rearing these stars in captivity. Here we report observed feeding behaviors and cannibalistic patterns observed among developing juvenile *P. helianthoides* reared in laboratory conditions. Through structured feeding experiments and months of observations, we found that juvenile *P. helianthoides* are largely opportunistic eaters who may resort to cannibalism when: (1) provided with insufficient alternative foods; (2) when stars of differing sizes are incidentally in close proximity to each other; or (3) in cases of injury or death of another star. Juvenile seastars exhibited active predatory behaviors, often triggering flight responses in conspecifics. These findings are significant because *P. helianthoides* populations were devastated by wasting disease and conservation efforts are limited by a lack of established rearing protocols. Our research could be used to inform how future *P. helianthoides* rearing and conservation projects are structured in order to minimize juvenile mortality due to cannibalism.

**DEVELOPING SPATIALLY EXPLICIT TOOLS TO MINIMIZE COSTS AND MAXIMIZE THE BENEFITS OF ONGOING MARINE INVASIVE SPECIES CONTROL** *(YOUTUBE)*
Davis, A.C.D.*; Green, S.J.

*University of Alberta*

Invasive species are a global economic and ecological problem and are responsible for billions of dollars in environmental damages annually. Invaders transmit disease, prey on and outcompete native species, and are one of the leading causes of recent extinctions leading to alterations in native communities. The effects of invasive species can vary, so understanding and managing species invasions requires ecological and socio-economic information at multiple spatio-temporal
scales. Management plans should include accurate mapping of the invasive species’ range, assessment of the effects of invasive species on native species, quantification of micro-habitat selection and use by invasive species, and assessment of removal efforts and suppression costs. The aim of this project is to create a modeling framework that can be modified for various invaded marine systems. Using information on removal efforts, population densities, environmental and habitat conditions, and efficiency of gear and personnel we can predict cost and efficacy of removal efforts. With model outcomes integrated with management goals we can create conservation management tools designed to prioritize sites of value for focused population control. Tools like these allow managers to input details directed towards their priorities and create conservation plans that have the lowest socioeconomic strain. Currently, we are modeling invasive lionfish (Pterois spp.) in US Atlantic and Caribbean territories, and are expanding to the spreading invasion of European green crab (Carcinus maenas) in the Salish Sea.

THE HIDDEN ARMY: THE EFFECT OF A PROLONGED HERBIVOROUS PHASE ON THE GROWTH OF JUVENILE CROWN-OF-THORNS-STARFISH (YOUTUBE)
† Dione Deaker*; Maria Byrne

The University of Sydney

Population outbreaks of the corallivorous crown-of-thorns starfish (COTS) that decimate tropical coral reefs can only arise when the initially herbivorous juveniles transition to their adult diet of coral. This ontogenetic diet switch is poorly understood, yet is key to modelling COTS population dynamics and predicting the timing of outbreaks. We show that COTS juveniles are able to survive on an algal diet for substantially longer than previously known. We monitored the growth of two cohorts of juveniles fed crustose coralline algae (CCA) for 10-months and 6.5 years and then offered both cohorts coral. Both cohorts achieved an asymptotic size (16 – 18 mm diameter) on algae and had similar exponential growth on coral. The similar size of both cohorts shows that juveniles can persist on a CCA diet for years but have limited growth and that this does not impact their competency as coral predators. This trophic and growth plasticity is likely to result in a delay from larval settlement to the predator-outbreak stage if coral is scarce. The potential that a hidden army of herbivorous juvenile COTS may be a source of outbreaks has major implications for the source-sink models of COTS populations that are used to inform management of this keystone predator.

EVALUATING PERFORMANCE OF CALIFORNIA'S MPA NETWORK THROUGH THE LENS OF SANDY BEACH AND SURF ZONE ECOSYSTEMS

Dugan, JE1*; Ladd, M 1; Madden, J 1; Hubbard, DM 1; Hamilton, S 2; Koval, G 2; Neumann, K 3; Robinette, D 3; Lindquist, K 4; Marin-Jarrin, J 5; Cowell, M 5; Blair JO 5; Terhaar, K 5; Nielsen, KJ 6

1- Marine Science Institute, University of California, Santa Barbara 2- Moss Landing Marine Laboratory, San Jose State University 3- Point Blue Conservation Science 4- Gulf of the Farallones Association 5- Humboldt State University 6- Estuary and Ocean Science Center, San Francisco State University

Sandy beaches and their surf zones make up a large proportion of the open coast of California and are significant components of many MPAs statewide. The strong connections of beaches to rocky habitats, especially kelp forests, are key ecological pathways through which direct and indirect effects of MPA protection can cascade. This makes sandy beaches and surf zones important ecosystems for evaluating the performance of the State’s MPA network. Our project goals for using beach and surf zone ecosystems to address MPA performance are two-fold. We are exploiting the bottom up effects of ecological connectivity of sandy beaches with kelp forests and rocky reefs to assess indirect effects of MPAs using data on abundance and composition of kelp subsidies and
birds. We are assessing direct effects of MPAs by surveying the abundance, biomass, size and diversity of surf zone fish, including ecologically and culturally important species that could respond to protection from fishing, such as surfperch, croakers, sharks, and rays. Our study design relies on beaches inside MPAs paired with carefully selected reference beaches for a total of 28 sites for fish and 36 sites for birds statewide, including central coast MPAs that were not surveyed in baseline studies. In 2019, we caught and released >9000 fish of 48 species in beach seines and found strong regional patterns. We observed 39,000 birds of 102 species and >31,000 kelp plants on the study beaches and surf zones in monthly surveys. For shorebirds the most abundant species were sanderlings followed by western snowy plovers.

**INCORPORATING COMMUNITY ECOLOGY INTO RECOVERY PLANNING FOR HARVESTED SPECIES (YOUTUBE)**

Dunn, R.P. 1*; Samhouri, J.F. 2; Baskett, M.L. 3

1- University of South Carolina 2- Conservation Biology Division, Northwest Fisheries Science Center 3- University of California Davis

Outcomes of management efforts to restore populations of harvested species can be highly dependent on environmental and community context. Predator-prey interactions can alter recovery trajectories, and the timing of management actions when both predators and prey are harvested may influence the dynamics of recovery and lead to management trade-offs. Here, we use a tri-trophic level rocky reef community dynamics model with size-structure and fisheries at multiple trophic levels to investigate the importance of four community ecology processes to recovery of predators and prey from harvest: 1) size-structured predation, 2) non-consumptive effects of predators on prey behavior, 3) varying levels of recruitment, and 4) alternative stable states. Predator-first recovery generally leads to the least volatile and quickest recovery, whether from a kelp forest, urchin barren, or bistable state. The benefits gained by selecting this strategy are magnified when recovering from the degraded community, the urchin barren, because initial conditions in the degraded state cause lengthy recovery times due to hysteresis. However, the shape of the size-structured predation relationship can strongly affect recovery volatility, where the differences between alternate management strategies are negated with size-independent predation. External recruitment reduces return times by bolstering the predatory lobster population. Given the ubiquity of species loss and the potential for tipping points to impede recovery, we highlight the value of incorporating community ecology into ecosystem management.

Session 20: Fisheries Ecology 2

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

**JUVENILE CALIFORNIA HALIBUT INDEX OF ABUNDANCE (YOUTUBE)**

Miranda B. Haggerty*; Charles F. Valle

*California Department of Fish and Wildlife*

The California Halibut (Halibut), *Paralichthys californicus* has been a valuable commercial and recreational fishery for over a century. Like many temperate fishes in the Southern California Bight, Halibut abundance fluctuates and may increase with warmer water conditions. In 2018, the California Department of Fish and Wildlife (CDFW) began conducting biannual fishery-independent trawl surveys targeted at juvenile Halibut. Juvenile Halibut spend their first couple of years exclusively in shallow offshore locations and embayments. To evaluate distribution, relative abundance and expected contributions to the fishery, swept area trawl surveys are being conducted at 13 locations from San Diego to Los Angeles. Sampling methods follow past CDFW trawl surveys.
conducted from 1993 – 1995 to ensure standard net parameters, survey locations, depths and trawl times. The 1994 year captured an El Niño and corresponding peak in fishery recruitment reflected five years later in Halibut landings. Current sampling efforts across two years, four seasons, shows significant variation but some consistent trends are seen between locations. Bays and harbors yield a significantly higher number of juvenile Halibut per area compared to coastal locations. These trends were also seen in past sampling efforts, however, Halibut density today is significantly lower than the 1994 peak. Continued monitoring over time is necessary to corroborate trends and inform models forecasting future Halibut yield.

Management action to enhance red sea urchin (Mesocentrotus franciscanus) fishery in El Rosario, Baja California, Mexico. (YOUTUBE)
† Hernández-Castillo, A.; Malpica-Cruz, L.; Zepeda-Dominguez, J.A.; Medellín-Ortiz, A.

Universidad Autónoma de Baja California

Kelp forests are coastal marine ecosystems dominated by kelp foundation species (mainly Macrocystis pyrifera) providing food and shelter for marine communities and constitute one of the most productive ecosystems on the planet. Marine heatwaves can have dramatic negative effects on kelp forest ecosystems, and thus were greatly affected by warming events. As these impacts drive kelp down, they will lead to lower food availability for ecologically and economically important grazing herbivores dependent of these. Globally, fishing provides a highly nutritious animal protein source, employment and income opportunities. In Mexico, the red sea urchin (Mesocentrotus franciscanus) fishery is economically important because it sustains an estimated 1600 direct and indirect jobs. One of the main producers that harvest red sea urchin is located in El Rosario, Baja California, Mexico. Despite having a high density population of red sea urchin, their gonadosomatic index (GSI) is low, making them unprofitable for fishing. Therefore, a “transplant” management strategy is being implemented. This strategy consists of taking red sea urchins with low GSI, transporting and releasing them in a specific location where the abundance of macroalgae (mainly Macrocystis pyrifera) is larger. This allows the organism to graze in the kelp forest and increase its GSI for future harvesting and commercialization. We aim to evaluate and document the status and characteristics of this strategy, using fisheries data to assess GSI changes overtime of transplanted individuals. In addition, we interviewed fishers

MARINE EXTIRPATIONS LAG BEHIND COLONIZATIONS ACROSS NORTH AMERICAN SHELF REGIONS (YOUTUBE)
† Kitchel, Z.J.1; Pinsky, M.L. 2

1- Ecology and Evolution Graduate Program, Rutgers University 2- Department of Ecology, Evolution, and Natural Resources, Rutgers University

Changes in climate have led to species range shifts and subsequent changes in biodiversity worldwide. While globally species richness is declining, patterns in diversity vary at the local and regional scales. Marine ecosystems provide relatively few biogeographical barriers, and therefore serve as natural experiments to examine how interactions between species traits and changing climate patterns can influence distributions and changes in richness. In particular, because aquatic species are highly sensitive to changes in water temperature, marine habitats are ideal systems to examine how species respond to warming. Here, we aim to address two questions, first, can we use temperature extremes experienced through time to predict instances of local colonization and extirpation? And second, can we use species’ traits to predict the prevalence of climate driven range shifts? To explore how changes in temperature impact the likelihood of local colonization and extirpation, we identified instances in which benthic ectorhers entered or exited North American
continental shelf regions. We found that while temperature seasonality over the past year best predicts colonizations, temperature seasonality experienced three years previously best predicts extirpations. The lag associated with extirpation may be explained by extinction debt, as it can take populations longer to leave a previously inhabited region than to invade a new region. When traits were considered, variation in maximum age and age at maturity across species influenced how colonizations and extirpations responded to chan

**Using otoliths to identify and age blue-footed booby (Sula nebouxi) fish prey in central Galápagos Islands (YOUTUBE)**

Marin Jarrin, J.R. 1*; Anchundia, D. 2; Schuiteman, M.A. 1; Anderson, D. 3

1- Department of Fisheries Biology, Humboldt State University 2- Department of Behavioral Biology, University of Vienna, Austria 3- Department of Biology, Wake Forest University

Forage fish in the Clupeidae and Engraulidae play a key role in many marine habitats, including as a main prey item for marine birds such as blue-footed boobies, Sula nebouxi. Despite this importance, in Galápagos these fish have been poorly studied. We opportunistically collected 76 fish from blue-footed booby (Sula nebouxi) regurgitations at three islands in central Galápagos to identify prey and explore the potential use of otoliths (fish ear bones) to age forage fish in the diet. Thirty-two Pacific sardines (Sardinops sagax), 31 Galápagos thread herrings (Opisthonema berlangai), and 13 slender anchovies (Anchoa ischana) were identified using fish morphology; otolith shape accurately identified each item to its morphological species. Using three methods, we also aged S. sagax; the method that was least affected by digestion was otolith weight, which showed an average age of 5.7 ± 2.0 yr. (±SD). Our results show that in addition to allowing fish species identification, otoliths can be used to indicate the age of blue-footed booby prey items for which otolith-age methods have been developed.

**Development of a Benthic Observation Survey System to Survey Rocky Habitats in California (YOUTUBE)**

Matthews, K. 1*; Starr, R. 1; Fields, R. 1; Cieri, K. 1; Mohay, J. 1; Gleason, M. 2; Kecy, C. 3; Cazenave, F. 3

1- Moss Landing Marine Laboratories 2- The Nature Conservancy 3- Monterey Bay Aquarium Research Institute

The West Coast groundfish fishery is composed of over 90 species, many of which are vulnerable to overfishing due to their long lifespans and late age of maturity. Rockfishes in particular have been subject to overfishing, with many stocks only recently declared recovered. The primary fishery-independent data set for monitoring groundfish stocks is the annual West Coast Groundfish Bottom Trawl survey, which is conducted almost exclusively on low-relief, soft-bottom trawlable habitats. In partnership with the Nature Conservancy and the Monterey Bay Aquarium Research Institute, we developed a light-weight, rapidly-deployable video lander, known as the Benthic Observation Survey System (BOSS). We use the BOSS to survey rockfish species in high-relief rocky habitats. The BOSS is equipped with 4 sets of stereo-paired, HD-prosumer cameras that are attached to a load-bearing fiber-optic cable that facilitates quick deployments and real-time monitoring of surveys. We use EventMeasure software (SeaGIS, Australia), to analyze the videos collected from the BOSS to provide information about the densities and length distributions of fishes. This powerful tool will provide insight into the status of rockfish and other groundfish populations.

**NATURAL MORTALITY RATE OF SUB-LEGAL DUNGENCESS CRABS**

† McLeod, M.*; White, W.; Henkel, S; Chan, F.

*Oregon State University
The Oregon Dungeness crab (*Metacarcinus magister*) fishery is strategically managed such that in a given year, the entirety of the legal-sized male crab cohort (4-5 year-olds) are expected to be harvested within the season. As such, our ability to forecast the scale of the harvest in a season depends on developing reliable estimates of the mortality rate of young sub-legal-size crabs in the previous year. The natural mortality rate is also an important parameter in population and bio-economic models applied to the Dungeness crab fishery. By conducting trap surveys off the Oregon coast (approximately monthly, April to September), we estimated the natural mortality rate of sub-legal crabs. Estimating the mortality rate of crabs from such surveys is challenging because the sampling period spans the molting season. Furthermore, estimates must account for the probability of molting and the change in size due to molting. Our approach to accounting for molting transitions leads to unexpectedly high estimates of natural mortality. We are re-evaluating the best way to account for both molting and mortality in within-season surveys. Mortality rates can improve our understanding of crab population dynamics and our ability to forecast crab landings.

**UNTANGLING ECOSYSTEM AND ENVIRONMENTAL VARIABILITY IN KELP FOREST FISHERIES IN MÉXICO.**

† Medellín-Ortiz, A.1*; Montaño–Moctezuma, G. 2; Álvarez–Flores, C. 3; Santamaría-del-Ángel, E. 1; García–Nava, H. 2; Beas–Luna, R. 1; Cavanaugh, K. 4

1- Universidad Autónoma de Baja California - FCM 2- Universidad Autónoma de Baja California - IIO 3- Pronatura Noroeste, AC. 4- UCLA Institute of the Environment and Sustainability

Red sea urchin fishery is one of the most important fisheries in Baja California and the only urchin fishery in México. Present study focuses on understanding how local, regional and oceanic environmental variability may affect red sea urchin populations. GLM’s were developed for different thermal conditions: Pre – heatwave, heat wave, and post – heatwave, as well as for sites above, below and average SST. Variables included in the models were kelp biomass, red sea urchin, California sheephead, kelp seabass and spiny lobster catches, SST, wave potency, upwelling index, MEI and NPGO. Kelp biomass was higher in ITS – PBan – ST. Previous results showed ITS, PBan and PBaj as sites with higher red sea urchin population densities; California sheephead highest catches were recorded in PBan and PBaj, while kelp seabass catch was higher in Can, and spiny lobster catch was higher in PBaj – ISJ – AS. We observed that local environmental variability, food availability, predator abundance are more important on determining red sea urchin population changes, compared to regional (upwelling index) and oceanic scale variables (MEI and NPGO). We also found that these variables change in importance depending on the spatial and temporal scale that is considered, meaning that “normal or average” conditions are regulated by different variables compared to extreme environmental conditions such as El Niño or the Blob events. Improving management of the red sea urchin fishery might yield benefits for the entire kelp forest ecosystem, fishermen and red sea urchin populations in Mexico.

**Globalization as an adaptive response to climate change in Maine’s lobster industry**

† Oldach, E.J.1*; Stoll, J.S. 2; Witkin, T. 2; Love, D.C. 3; Reardon, K. 4; Pinto da Silva, P. 5

1- University of California, Davis 2- University of Maine, Orono 3- Johns Hopkins Bloomberg School of Public Health, Johns Hopkins University 4- Maine Department of Marine Resources 5- Northeast Fisheries Science Center

Climate change is catalyzing shifts in the marine environment and, in turn, necessitating adaptation by marine resource users. In the Gulf of Maine, one of the observed changes is a decline in fishing quotas for Atlantic herring, as fishery managers seek to protect the stock from harm caused by declining populations of their primary food source, the copepod Calanus finmarchicus. However,
Maine’s iconic lobster industry has been heavily reliant on herring for bait, and the reduced quota forced the industry to adapt to a “bait crisis” in 2019. In this study, we analyzed adaptive efforts on the individual and group level. Ultimately, we observed that: (1) fishers escaped a cultural attachment to herring; (2) suppliers built capacity to source alternative bait options; and (3) policymakers institutionalized pathways to support bait trade. Furthermore, our findings highlight the role of globalization as an adaptive response to climate change, raising questions about the double-edge of vulnerability and adaptation in an increasingly connected and rapidly changing world.

Session 21: Intertidal Ecology 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

POPULATION VARIATION IN AN INTERTIDAL PREDATOR SHAPES HABITAT STRUCTURE AND COMMUNITY COMPOSITION (YOUTUBE)
Contolini, G.M. 1*
; Palkovacs, E.P. 2

1- California Sea Grant 2- UC Santa Cruz

Population-level trait variation is an important form of biodiversity that can alter community and ecosystem properties. While recent work shows the ecological importance of population-level trait variation, few studies describe this for predator-prey interactions, especially for predators consuming foundational prey. In marine systems, where populations are traditionally viewed as open and highly connected, much debate exists about the importance of intraspecific trait variation. Here we test the prediction that intraspecific foraging differences among populations of a marine intertidal predator (*Nucella ostrina-emarginata*) differentially alter California mussel bed communities by altering mussel bed structure. In a nine-month field experiment, we measured mussel bed structure and community composition within the matrix after treatment with *Nucella* from one of three populations. Using a piecewise structural equation model, we identified a pathway through which *Nucella* foraging can decrease Shannon diversity within the matrix: larger drilled mussel size increased remaining mussel size which decreased Shannon diversity. As the different *Nucella* populations on average drilled significantly different sizes of mussels, our results show that intraspecific variation in *Nucella* foraging can differentially alter mussel bed communities via changing mussel bed habitat structure. These results support the hypothesis that population-level variation in predators can have community consequences in marine ecosystems.

CLAM GARDEN BIVALVE RESPONSES TO ENVIRONMENTAL STRESSORS INDICATE SALINITY-DRIVEN PHYSIOLOGICAL RESPONSES AFFECT BIVALVE CONDITION (YOUTUBE)
† Cruz, O. A.1†; Thurber, A. 2; Reid, S. 1; Hatch, M.B.A. 1

1- Western Washington University 2- Oregon State University

Indigenous communities in the Pacific Northwest (PNW) have historically managed ecosystems to support a vibrant foodscape. Clam gardens (CG) are a form of traditional Indigenous aquaculture that involved creation of rock-walled beaches, and have been found to increase bivalve growth rates, juvenile survivorship, and clam densities. Understanding the mechanistic drivers behind increased bivalve growth rates will assist Indigenous lead clam garden restoration. We examined physiological differences between littleneck clams (*Leukoma staminea*) to determine drivers for bivalve condition indices related to environmental parameters over clam gardens. We focused on examining dietary fatty acid methyl ester (FAME) profiles, 13 C and 15 N stable isotope markers, and bivalve condition indices to temperature, salinity, and dissolved oxygen levels. We found that CG *L. staminea* clams occupy different isotopic niches than control *L. staminea*, with higher trophic
positioning (^15 N) and more simplified dietary food webs (^13 C). Bivalve FAME species in CGs were statistically different than control sites, with higher saturated fatty acids and lower monounsaturated fatty acid levels. Clam garden bivalves had higher health condition indices which correlated to salinity and SFA FAME shifts observed in a canonical redundancy analysis model. Main modeling results suggest that salinity is a main driver in clam garden systems, increasing CG L. staminaea condition indexes compared to control sites where low salinity drives reduced feeding, indicated by dietary FAs and trophic niche shifts.

SEA STAR WASTING SYNDROME: UPDATE ON INTERTIDAL SEA STAR POPULATIONS FROM MULTI-AGENCY ROCKY INTERTIDAL NETWORK (MARINE) MONITORING (YOUTUBE)
Douglas, M.A.; Fletcher, N.C.

University of California, Santa Cruz

Sea star wasting syndrome (SSWS) describes a set of symptoms that affects more than twenty sea star species along the west coast of North America. SSWS was first observed in 2013 by MARINE researchers in Washington, and has since impacted sea star populations from Alaska to Mexico. SSWS is considered one of the largest marine disease outbreaks ever recorded. The disease has resulted in massive declines of the once ubiquitous ochre star, Pisaster ochraceus. Populations of P. ochraceus at virtually all MARINE long-term monitoring sites have experienced significant declines, and the majority show little sign of recovery. Key to recovery is larval recruitment and juvenile survivorship, which has exhibited strong regional patterns. Recruitment has generally been higher in the north vs south, and juvenile survivorship has been high at some sites in northern California and Washington. However juveniles at sites in central California have virtually disappeared, and no evidence of recruitment has been observed in southern California. This, coupled with a continued, low-level presence of SSWS in all regions, suggests that recovery will be slow throughout much of the ochre star’s range. Having a long-term monitoring program in place provided pre-disease data, early detection of SSWS and has tracked the impacts and progression of the disease. MARINE has also welcomed the input of other researchers as well as community scientists by encouraging submissions of observations to seastarwasting.org, where MARINE continues to track the disease via an interactive map.

EXPERIMENTAL EVIDENCE OF LOW DOSAGE AND WATER BORNE TRANSMISSION OF EELGRASS WASTING DISEASE IN NATURE (YOUTUBE)
† Eisenlord, M.E.1; Agnew, M.V.2; Winningham, M.1; Miller, O.1; Vompe, A.3; Wipple, B.4; Friedman, C.4; Harvell, C.D.1; Burge, C.A.2

1- Department of Ecology and Evolutionary Biology, Cornell University 2- Institute of Marine Environmental Technology, University of Maryland Baltimore County 3- Department of Microbiology, Oregon State University 4- School of Aquatic and Fishery Sciences, University of Washington

Transmission dynamics are fundamental to understanding the epidemiology of infectious diseases; however, in marine systems they are poorly understood. In this study, we explored transmission in marine habitats through a series of field and laboratory experiments on eelgrass wasting disease (EGWD) caused by Labyrinthula zosterae (Lz). EGWD is found in temperate seagrass beds worldwide and has the potential to devastate important coastal habitats. To test in situ transmission modes, we out-planted sentinel eelgrass shoots within and up to 300 meters adjacent to a natural eelgrass bed. Infection rates and infection severity did not differ significantly among distances, providing clear evidence for transmission through the water column as well as by direct contact. The infectious dose of Lz through waterborne exposure and the temperature sensitivity of the infection process were assessed in a controlled laboratory experiment. The dose to 50%
infection was only 6 cells mL\(^{-1}\) and was not impacted by temperature. Warm temperature led to increased EGWD infection severity and pathogen load at high exposure doses. Our results show *Lz* is highly virulent and readily transmits through without direct contact with infected plants. The complex transmission dynamics of this disease in the context of changing ocean conditions has implications for eelgrass protection and restoration in critical coastal habitats worldwide.

**THE DIMES NETWORK: DIVERSIFYING AND INTEGRATING MARINE EDUCATION AT STATIONS ALONG THE NORTH AMERICAN WEST COAST**

Elahi, R.\(^1\); Beas-Luna, R.B.\(^2\); Benes, K.M.\(^3\); Galloway, A.W.E.\(^4\); Haupt, A.J.\(^5\); Hochstaedter, A.\(^6\); Micheli, F.\(^1\); Neufeld, C.\(^7\); Raskoff, K.A.\(^6\); Denny, M.W.\(^1\)

\(^1\) Hopkins Marine Station, Stanford University
\(^2\) Universidad Autónoma de Baja California
\(^3\) University of Montana
\(^4\) Oregon Institute of Marine Biology, University of Oregon
\(^5\) California State University, Monterey Bay
\(^6\) Monterey Peninsula College
\(^7\) Bamfield Marine Sciences Centre

Hands-on learning in nature is transformative and has positive outcomes on student knowledge and long-term engagement with science. Field courses share a common philosophy centered on local natural history and experiential learning, but this knowledge is rarely placed within a broader geographic context in an explicit, quantitative manner – a shortcoming in an era of global human impacts. The DIMES network will integrate the traditional place-based approach within a biogeographic framework by developing educational modules that combine data across the network to address questions at larger spatial and temporal scales. By linking explicitly climate change, biogeography, and the natural history of intertidal shores, the DIMES network will maintain the relevance of curricula offered at these stations and export the modules to other institutions. By connecting participants from a variety of academic institutions, the DIMES network will diversify the undergraduate audience served by marine stations. This network will leverage the existing undergraduate teaching at participating marine laboratories and expand their reach to new students who lack access to experiential learning. We view the transition to virtual classrooms for the current academic year as a grand opportunity to implement our vision.

**Impacts of multiple stressors on the lability of Fucus distichus tipping points**

† Emry, S.M.\(^*\); Harley, C.D.G

*University of British Columbia*

Marine communities are constantly exposed to multiple sources of anthropogenic stress that vary in magnitude, and intensity. Even sublethal levels of stress can slowly degrade the resilience of ecosystems until a tipping point is reached, creating catastrophic shifts in biodiversity and function. These shifts, known as ‘ecological surprises’, are difficult to predict due to both a poor understanding of how stressors interact to affect performance at the individual level due to non-linearities, as well as inter-population differences resulting from local adaptation to heterogenous environments. I investigated how key physiological thresholds of Fucus distichus, a foundation species of algae distributed along the Northeast Pacific coast, shift under multiple stressors. I cultured *F. distichus* in seven temperatures (2, 8, 12, 16, 20, 24 and 28 °C), and three levels of salinity (5, 15 and 30 psu) commonly experienced along the coast, using two distinct populations (n=6). I found that germination rates of zygotes decreased more strongly at high temperatures when also grown in lower salinity, and this effect was magnified for the population locally adapted to high salinity. Similarly, growth rates were suppressed under high temperature and low salinity, with both the thermal optima and critical thermal maxima shifting to lower temperatures for both populations. This research highlights the need for integrating both the dynamic nature of stress in
marine environments, as well as genetic differences among populations, if we are to make accurate predictions about response to change.

**HOT SUMMER TIDES: PHOTOSYNTHESIS AND GROWTH RATE OF AN INTERTIDAL KELP**
† Fales, R.J.; Carrington, E.

*University of Washington*

Climate change is increasing the frequency and severity marine and aerial heatwaves which, for intertidal organisms, impose stressful water and aerial temperature conditions. Most kelps are subtidal or only experience very short periods of emersion, but *Hedophyllum sessile* (Laminariales) inhabits the abiotically dynamic low intertidal zone and provides important habitat from central CA to British Columbia. Unlike most of the West Coast, extreme low tides in the Salish Sea occur in daylight hours during summer making this region a hot spot for aerial temperatures and an interesting place to examine the effects of aerial temperature stress. Therefore, we investigated the ability of *H. sessile* to photosynthesize and grow during hot summer conditions. We measured growth rates of *H. sessile* in the field on San Juan Island, WA. In a lab experiment, we tested the ability of entire *H. sessile* thalli versus excised tissue plugs (a standard method in macroalgae physiology studies) to recover from repeated 4-hour low tide treatments of ambient and heatwave temperatures. Thalli and tissue plugs survived and continued to photosynthesize in the ambient temperature low tide treatment. In the aerial heatwave treatment, however, tissue plugs did not recover after the first low tide exposure while entire thalli survived but experienced reduced photosynthetic rates. Our results suggest that macroalgae with complex morphologies such as *Hedophyllum* are better studied using the entire thallus instead of tissue plugs and *H. sessile* may fare poorly under future climate conditions.

**TRENDS IN VERTICAL DISTRIBUTION OF MYTILUS CALIFORNIANUS AND THEIR PREDATORS ALONG THE OREGON AND CALIFORNIA COASTLINES**

Field, L.C; Gravem, S.A; Raimondi P.T.; Menge B.A

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

The vertical zonation of intertidal species is typically controlled by abiotic stressors at the upper limits and by biotic interactions at the lower limits. Anthropogenic climate change is accelerating, which will result in sea level rise, higher air temperatures, and changes to upwelling patterns. However, it is still unknown how these factors will affect the vertical ranges of intertidal species at various latitudes on the US West Coast. We investigated the vertical zonation and overlap of the ecosystem engineer, *M. californianus* and its multiple predator species, including 2 sea stars and 3 whelks (*Pisaster ochraceus, Leptasterias spp., Nucella ostrina, N. emarginata*, and *N. canaliculata*) at 30 sites from Central OR to Southern CA. We found that the upper limits of both predators and prey shift seaward at southern sites, presumably due to increased air temperatures, decreased tidal amplitude, and decreased wave run up. Preliminary comparisons indicate that for all predators, lower limits also shifted downwards at southern sites. We investigate whether mussel zones also shift downward, or whether “squeeze effects” are causing vertical range contractions at southern sites. By comparing densities and vertical overlap of the 5 predators and mussels, we investigate which predators may be driving the patterns seen in mussels. These investigations may demonstrate whether vertical contraction of species’ ranges may be a mechanism leading to the recently-detected northward shifts (several kilometers per year) for intertidal communities on the US West Coast.
LARVAL SETTLEMENT RESPONSES TO TURBULENCE IN THE SUNFLOWER SEA STAR, PYCNOPODIA HELIANTHOIDES
Anteau, F.P.*; Cefalu, S.N.; Pearson-Lund, A.; Hodin, J.

University of Washington

Biphasic life histories that include a pelagic larval stage and a benthic adult stage are extremely common among marine invertebrates. As the adult forms of benthic invertebrates generally have drastically reduced dispersal capabilities when compared to larvae, accurate selection of favorable habitats to settle is vital to long term survival. Here, we report the findings of experiments on larval responses of the sunflower sea star, Pycnopodia helianthoides, to turbulence exposure. Prior work has found that echinoids that live in habitats with high wave activity tend to respond to turbulence as a settlement cue. Our research has demonstrated that sunflower sea star larvae respond to both manual and Taylor-Couette cell produced turbulence by being more likely to settle when exposed to inductive biofilm shortly after turbulence exposure. Understanding both laboratory and field conditions that might promote settlement of P. helianthoides is a key piece of information in the eventual recovery of this species from its massive declines in the NE Pacific due to seastar wasting disease. These declines are especial cause for concern as the sunflower sea star is suspected of having a vital ecological function. In its native kelp forest ecosystem, disappearances of the predatory star have coincided with increases in purple urchins (Strongylocentrotus purpuratus) and decreases in bull kelp (Nereocystis luetkeana). (F.P.A. and S.C. contributed equally)

SARGASSUM VS MACROCYSTIS:HOW A FERTILE FUCOID INVADED THE KELP FOREST (YOUTUBE)
Bishop, A.M.*

Moss Landing Marine Labs

Climate change is increasing the frequency and intensity of both ENSO events and marine heatwaves within giant kelp forest ecosystems in California. The combined stressors of increased temperatures and invasive species have led to population-scale consequences for foundational native species in other systems and may have similar consequences for the kelp forest. This study examined how the distinct reproductive strategies for Macrocystis pyrifera and Sargassum horneri may have facilitated the fucoid's invasion on Catalina Island during and after the 2015/2016 El Niño. I conducted monthly in-situ surveys off the western coast of Catalina between July 2018 & August 2019 and sampled population densities and reproductive output. Although giant kelp was larger, S. horneri contributed a larger proportion of its biomass to reproduction and released its fertilized zygotes before giant kelp’s primary reproductive period. Preliminary data suggests that temperature plays a role in the macroscopic recruitment differences in the species. These findings give insight into S. horneri's invasion success and may inform better management strategies for S. horneri introductions into other novel habitats.

RECRUITMENT OF JUVENILE HAWAIIAN CORALS IN CONTRASTING ENVIRONMENTS (YOUTUBE)
† Dilley, E.R.*; Brush, E.G.; Jones, R.N.; Hixon, M.A.

University of Hawaii at Manoa

Coral populations persist via recruitment of juvenile corals and their survival and growth into adults. We monitored coral recruitment on cubic-meter concrete modules at a relatively degraded reef off Waikiki and a relatively pristine reef at Hanauma Bay, both on the south shore of O’ahu,
Hawai‘i. Modules were built with low and high shelter availability (n=3 each) at both sites in the summer of 2016 and were censused for corals quarterly from May 2017 to March 2020. Corals of the genera Pocillopora, Porites, and Montipora recruited to the modules and were monitored until they died or were last measured. We hypothesized that recruitment within sites would be greater on high shelter modules due to greater herbivore abundance and less benthic algae. Between sites, we hypothesized that recruitment would be greater at Hanauma Bay, where natural reefs have higher coral cover, more abundant herbivores, and lower nutrient runoff that fertilizes algae. We found that Pocillopora recruitment was initially greater at Waikiki regardless of shelter treatment yet was equal between sites for the largest size classes. Recruitment of Montipora was greatest on high shelter modules at Hanauma Bay, whereas Porites was not different between sites or shelter treatments. Because larger juvenile Pocillopora were equally abundant across sites despite greater recruitment of smaller colonies at Waikiki, and because Montipora recruitment was greater at Hanauma Bay, we conclude that reefs with more coral, more herbivores, and less nutrient runoff will likely recover better from future disturbances.

**LARVAL FISH DEPTH PREFERENCES ALTER DISPERSAL PATTERNS AND INFORM CONSERVATION PLANNING (YOUTUBE)**
† Killeen, H.J.‡; Morgan, S.G.; Largier, J.L.

*Coastal & Marine Sciences Institute, UC Davis*

Larval behavior strongly influences dispersal during early life history stages for a variety of marine species. Consequently, understanding larval behavior is important for predicting population connectivity and recruitment patterns. Unfortunately, larval behaviors are poorly documented for many marine fish species, undermining the utility of dispersal models in marine conservation planning. We present findings from a multi-year study on the behavior and dispersal of larval fishes off the central coast of California. We sampled plankton during the spring from 2017-2019 along two transects, at Bodega Bay (38.3° N) and Stewart’s Point (38.6° N) from 1 to 35 km from shore. All fish larvae were identified to species and developmental stages using morphological characteristics. Cross-shelf patterns in larval distributions reveal that over 75% of all nearshore fish larvae were retained within 10 km of shore even when offshore transport was strong. Moreover, we report distinct behavioral patterns regulating larval dispersal along and across the continental shelf for a diverse group of species. Larvae exhibited behaviors including stable and ontogenetically variable depth preferences as well as depth preferences cued by environmental conditions. Our findings suggest that behavioral regulation of dispersal is common among nearshore fish species in upwelling regions. Furthermore, the behavioral patterns documented in this study may serve to improve biophysical- and individual-based dispersal models used to predict spatial population connectivity and recruitment.

**GROWING UP IS HARD TO DO: SURVIVAL AND GROWTH OF GORGONIAN RECRUITS ON A CARIBBEAN REEF (YOUTUBE)**
Lasker, Howard R‡; Martinez Quintana, Angela

*University at Buffalo*

Among species with size structured demography, population structure is determined by the product of size specific survival and the growth rates that control size and thus survival. This interplay is particularly important among recently settled colonial invertebrates for which survival is low and growth is the only way of escaping a high mortality section of the life table. Gorgonian corals settling on reefs, if they survive, can grow into colonies that are meters tall and have 10^6 polyps. However, they all start their benthic lives as single polyps, which are subject to high
mortality rates. Annual survival among these species increases with size, reflecting in all likelihood, the ability of colonies to increasingly survive partial mortality as they grow larger. Survival and growth of gorgonian recruits in the genera *Eunicea* and *Pseudoplexaura* were monitored over 2 y on St. John USVI. The data were used to generate a stage structured model that characterizes growth of recent recruits from 0.5 cm until they reach 5 cm height. High probabilities of zero and negative growth increase the time necessary to reach 5 cm and exposes colonies to multiple years of mortality in this high mortality section of the life table. Less than 3% of the recruits in the model survive and reach 5 cm height. On average recruits require over 3 y to reach 5 cm height. The interplay between growth and survival generates a size structure in which 0.6-1.0 cm recruits are over twice as common as smaller recruits.

**USING INTERACTING ENVIRONMENTAL GRADIENTS TO PREDICT LARVAL SUCCESS IN FUTURE ENVIRONMENTS** (YOUTUBE)
† Lawlor, J.A.*; Arellano, S.M

*Western Washington University Department of Biology*

Impacts of multiple climate stressors in marine environments are complex, and traditional laboratory experiments are often limited in their capacity to accurately capture full functional responses of interacting variables. Decoding these multiple-stress interactions in high resolutions that encompass possible conditions of present and future environments is critical to fully grasp the impacts of climate change on marine life. Here, we use a novel experimental approach to test interactive effects of temperature, salinity, and acidification on growth rate and habitat suitability for larvae of the Olympia oyster, a species of key conservation concern in the US and Canada. We rear larvae in fifty unique combinations of environmental variables, then model growth rate and habitat suitability across treatment conditions. We find that temperature and salinity are closely linked to larval performance, but acidification had no effect. By incorporating field data from two sites of restoration focus and modeled data of present and future conditions in the Salish Sea, we assess performance of larvae in the region now and in the face of changing climate. We find that Olympia oyster larvae in the Salish Sea are not very well suited for environments in which they live and may actually benefit from some degree of global change, and we predict shorter larval durations, but increased growth and habitat suitability by the year 2095. Finally, we use these functional relationships to explore how larval environmental tolerance can explain distribution throughout the range of the species.

**EFFECTS OF ALTERED PH ON JUVENILE FEEDING RATES IN THE MARINE GASTROPOD CREPIDULA FORNICATA** (YOUTUBE)
† Litle, J.W.*; Pires, A. ; Pechenik, J. A.

*1- University of Washington 2- Dickinson College 3- Tufts University*

Today’s ocean surface is subject to increasing atmospheric carbon dioxide concentration, which lowers ocean pH and carbonate ion concentrations. The effects of ocean acidification (OA) on ecologically and economically important shell-forming mollusks are of growing concern. We investigated effects of OA on suspension feeding in recently metamorphosed juveniles of the gastropod *Crepidula fornicata*. Brooding adults were collected from southern Puget Sound, WA. Larvae were reared under controlled seawater conditions at pH 7.6 or 8.0. Upon metamorphosis, juveniles were transitioned to conditions maintained at pH 7.6 or 8.0, so that treatment groups represented 4 combinations of larval and juvenile pH experience. Clearance rates were measured by flow cytometry following introduction of *Isochrysis galbana*. Among juveniles reared at pH 8.0 and tested 36 h after metamorphosis, individuals from pH 7.6 larval cultures fed at lower rates than
those from pH 8.0 larval cultures. 2-4 d after metamorphosis, juveniles with equivalent larval pH experience fed at lower rates at pH 7.6 than at 8.0. However, clearance rates did not differ for older (20 d) juveniles that were reared as larvae in ambient seawater at pH 7.8-8.0 and, upon metamorphosis, reared at pH 7.6 or 8.0. The differences in clearance rates in young juveniles were most apparent in the first hour after food introduction. Results suggest a carry-over effect of larval pH experience on juvenile feeding. This may be an important consequence of OA for suspension feeders that exploit spatiotemporally variable food resources.

**VARIATION OF LARVAL TRAITS AND COPPER TOLERANCE IN AN INVASIVE CRYPTIC SPECIES COMPLEX (WATERSIPORA: BRYOZOA)**

Lopiccolo, J.A.*; Craig, S.F.

*Humboldt State University*

Bryozoans in the genus *Watersipora* display a high degree of invisibility and copper tolerance. It is also a genus plagued by taxonomic issues due to a lack of distinguishable taxonomic features and a history of uncertainty with type specimens. Clouding matters further, the most well studied species of *Watersipora* (*W. subtorquata*), has been found to be a cryptic species complex comprised of two separate species. These two species (*W. subtorquata* and *W. new species*) have been lumped together in previous published work, treating both as *W. subtorquata*, but little is known about what differences, if any, exist in their life histories. Individual *Watersipora* larvae were collected from cytochrome oxidase I genotyped colonies and placed in a common garden larval settlement experiment. Individual larvae were photographed and monitored for 72 hrs. to measure time until settlement and then again once every two weeks for 14 weeks. We show that there are broad differences in the larval size and settling behavior between *W. subtorquata* and *W. new species* including: time until settlement, rate of settlement, and rate of metamorphosis. Not only did patterns differ between species, but they sometimes reversed with the addition of copper antifouling paint onto the settlement surface. These differences suggest the two species may have different life histories and mechanisms of invasion. Failure to differentiate between *W. subtorquata* and *W. new species* and how they are able to invade new habitats could hamper research advancements as well as future management efforts.

Session 23: Community Ecology 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**CORALLIVORY, HERBIVORY, AND COMPETITOR IDENTITY MEDIATE INTERACTIONS BETWEEN TWO KEY CORAL GENERA ON AN INDO-PACIFICREEF**

† Clover, H.E.1*; Ladd, M.C. 2; Shantz, A.A. 3; Burkepile, D.E. 4

1- California State University, Northridge 2- NOAA Fisheries, Southeast Fisheries Science Center 3- New York University, Abu Dhabi 4- University of California, Santa Barbara

Spatial competition is a fundamental ecological process structuring community diversity and function. Many reefs have undergone shifts from coral- to algal-dominance, and thus coral-algal competition is a prominent research topic. However, coral-coral competition can also influence community structure. Many coral predators exhibit prey selectivity, yet we know little regarding how these choices mediate competitive outcomes. This study investigated how predation and algal presence altered spatial competition between two common coral genera, massive *Porites* and *Montipora*, in the back reef habitat of Mo’orea, French Polynesia. We conducted a year-long common garden competition experiment to analyze competitive interactions in the presence and absence of large coral predators and herbivores. We found that corals protected from predation, but
exposed to algal competition, grew 6-fold more than those exposed to predation. In the absence of predation, spatial competition had genus-specific effects on coral growth. For example, *Montipora* growth decreased for colonies paired with a coral competitor, regardless of identity. In contrast, massive *Porites* growth decreased when competing against conspecifics, but not heterospecifics. We found that coral predation had a larger effect than competition on the ability of *Montipora* and massive *Porites* to occupy space, and for some corals, competitor identity matters. These findings suggest that the interaction between coral competition and predation could be an important and overlooked driver of coral reef community structure.

**Community structure and ecosystem multifunctionality respond to a strong local-scale gradient in wrack subsidies (YOUTUBE)**

† Emery, Kyle; Dugan, Jenifer; Miller, Robert; Hubbard, David; Ohlman, J. Carter; Madden, Jessica

*UC Santa Barbara*

Connectivity that facilitates flows of organic matter across ecosystem boundaries can influence community assembly and ecosystem functioning. The magnitude of subsidies can affect the structure of communities and populations, creating food web effects that propagate across trophic levels. We explored how a strong natural gradient in subsidies of marine wrack from nearshore reefs affects community structure and functioning of sandy beaches along 100 km of coast. Detritivore diversity and the biomass of both detritivorous and predatory invertebrates increased significantly with wrack abundance. Predatory invertebrate biomass also increased with increasing prey availability (detritivore biomass). Higher on the food web, the species richness and abundance of vertebrate predators, represented by shorebirds, increased significantly with wrack abundance, invertebrate richness, and invertebrate abundance. A more synthetic view of the effects of variation in subsidies provided by ecosystem multifunctionality revealed pore water nutrients, CO2 flux, invertebrate richness, talitrid amphipod secondary production, flying invertebrate abundance, and shorebird richness were enhanced across a strong local-scale gradient in wrack subsidies. Sandy beach ecosystems that received more wrack subsidies had higher biodiversity, supported greater invertebrate biomass across multiple trophic levels, and exhibited higher ecosystem functioning. Our results suggest that maintaining cross-ecosystem connectivity is critical for coastal conservation efforts, including MPAs and beach management.

**CONDITIONS FOR THE PROPAGATION OF SEABIRD GUANO- DERIVED NUTRIENTS THROUGH KELP FORESTS (YOUTUBE)**

† Gabara, S.S.; Konar, B.H.; Edwards, M.S.

1- Coastal and Marine Institute, San Diego State University and Department of Environmental Science and Policy, University of California, Davis 2- University of Alaska Fairbanks, Alaska 3- Coastal and Marine Institute, San Diego State University

Connectivity of organic matter, nutrients, and materials can be critical to the structure and function of terrestrial and marine ecosystems. Here, we ask if seabird guano-derived nutrient subsidies increase connectivity between terrestrial and marine ecosystems using the Aleutian Island archipelago as a model island-kelp forest system. We address this question by comparing nitrogen stable isotope values of kelp forest primary producers and consumers, where high values can indicate consumer derived nutrient inputs, at islands that differ in seabird abundances and invasive predatory fox history. We also consider how upwelling, estimated from seawater temperature, and precipitation, estimated from seawater salinity, affect seabird guano-derived nutrient signals in kelp forest producers and consumers. We found signals of seabird guano-derived nutrients in kelp forest primary producers and consumers on islands where seabird abundance and precipitation
was high, foxes were present for shorter amounts of time, and upwelling was low. Increases in δ15N values from producers to consumers was consistent with propagation of seabird guano-derived subsidies through the kelp forest food webs. Collectively, these findings provide the conditions needed for seabird guano-derived subsidies to travel through nearshore Aleutian Island kelp forest ecosystems. A better understanding of where and when we expect terrestrial consumer subsidies to increase connectivity between and among ecosystems may help us increase ecosystem resilience in the face of environmental variability.

**MEGAFAUNA IN SALT MARSHES** *(YOUTUBE)*
† Gaskins, L.C. 1*; Paxton, A.B. 2; Silliman, B.S. 1

1- Duke University Marine Lab 2- CSS- Inc. for NOAA Office of Coastal Management

Megafauna shape ecosystems globally through trophic interactions, ecology of fear, and ecosystem engineering. Highly productive salt marshes at the interface of terrestrial and marine systems have the potential to support megafauna species, but a recent global meta-analysis of consumer-plant interactions in marshes found few studies investigated impacts of wild megafauna. We conducted a literature review to document the variety of megafauna in salt marshes and found that 34 species utilize salt marshes, including sharks, manatees, pinnipeds, crocodilians, sea otters, hippos, and large terrestrial animals, such as lions, bears and water buffalo. The use of salt marsh habitats by a variety of megafauna may have implications for both the conservation of these large consumers and for the resilience of coastal wetlands through stabilizing feedbacks on plant ecosystems. Future studies should quantify the occurrence and impacts of megafauna in salt marshes, and how their conservation can help restore these valuable ecosystems.

**Coral symbionts mediate the effect of sedimentation on corals**
† Fuentes, M.C.*; Bergsma, G.

*California State University Monterey Bay*

Coral reefs are biologically diverse and rely on a variety of symbiotic organisms to function and thrive. Some symbionts, including zooxanthellae and many arthropods and vertebrates, form close mutualisms with corals that influence how corals interact with their physical environment and affect their growth and coral reef community dynamics. For example, symbiotic gammaridean amphipods alter the physical structure of Montipora corals in Moorea, French Polynesia by creating branch-like “fingers”. These fingers have been shown to facilitate coral growth and survival. Coral morphology and structure can mediate physical factors such as sedimentation and water flow, therefore this change in morphology may indirectly affect coral sedimentation stress. In this study, we investigate the effect of these structural changes on sediment accumulation, and the impact this structure has on coral survival within different flow environments across a lagoon environment. Overall the presence of the amphipod-induced structure appears to decrease sedimentation stress. This species interaction sheds light on the complicated ecological and biological mechanisms influencing coral growth and survival which highlights the importance of considering the indirect effects of species interactions in coral reef studies and management.

**PREDATION DRIVES COMMUNITY ASSEMBLY IN EELGRASS-ASSOCIATED PERACARID CRUSTACEANS ACROSS LATITUDES** *(YOUTUBE)*
† Gross, Collin P. 1*; Stachowicz, John J. 1; ZEN Partners 2

1- UC Davis 2- Various
Empirical studies of community assembly processes typically focus on two major functional trait patterns at small plot-level or site-level scales. Communities with traits that are clustered relative to a null distribution are thought to be structured primarily by abiotic environmental filters, and overdispersed communities structured primarily by biotic interactions such as competitive niche partitioning. However, the patterns and drivers of community assembly may vary over broad geographic ranges. Using species abundance and trait data from 42 sites across the northern hemisphere spanning 37 degrees of latitude, we examined the assembly patterns of eelgrass (Zostera marina) -associated peracarid crustacean communities according to several abiotic and biotic environmental predictors in a model comparison approach. In virtually all models, predation emerged as an important predictor in models of dispersion – high predation intensity communities were more overdispersed and low predation intensity communities were more clustered, suggesting that partitioning of enemy-free space might contribute to overdispersion in predator-avoidance traits. Latitude also emerged as a strong predictor of dispersion – sites at low latitudes had more overdispersed communities, and those at higher latitudes had more clustered communities. In taking a global approach to understanding community assembly processes, our study allows us to pinpoint mechanisms common to all eelgrass communities, as well as detect where and how these mechanisms differ worldwide.

ARE WRACK-ASSOCIATED BEACH COMMUNITIES MODIFIED BY AN INVASIVE MACROALGA, SARGASSUM HORNERI?
† Harrison, L.N.; Anderson, T.W.

San Diego State University

Biological invasion is a major concern for numerous reasons, including the ability of invasive species to disrupt and alter subsidy flow between ecosystems. Sandy beaches, characterized by low primary productivity, are dependent on marine-derived subsidies. Stranded patches of kelp, algae, and seagrasses, referred to as "wrack", can support diverse invertebrate beach communities that rely on these resources for survival. These communities have been shown to utilize wrack patches differentially in response to a suite of morphological and physiochemical factors that ultimately influence species composition and abundance. To examine changes in beach invertebrate communities driven by the invasive alga, Sargassum horneri, a field wrack-manipulation experiment to determine any differences in invertebrate colonization was conducted, along with laboratory experiments on algal consumption and invertebrate growth. Differences between communities found in wrack composed of the native Macrocystis pyrifera versus S. horneri may occur across southern California as the occurrence of S. horneri is expected to increase in its distribution and abundance. The pale beach hopper (Megalorchestia benedictii), which is the dominant wrack grazer on San Diego beaches, was the focal species used in consumption and growth experiments. Beach communities are exposed to other anthropogenic stressors, resulting in multiple species experiencing regional declines and localized extirpations, further emphasizing the need to understand how S. horneri may affect sandy beach ecosystems.

CRUSTACEAN DIVERSITY IN THE PUGET SOUND: RECONCILING SPECIES, PHYLOGENETIC, AND FUNCTIONAL DIVERSITY
Hultgren, K.M.

Seattle University

Biodiversity has several dimensions—taxonomic, phylogenetic, functional—yet relatively few studies have explored patterns in the phylogenetic and functional diversity of marine communities. In this study, we surveyed environmental variables and intertidal crustacean communities at 11
sites in the Puget Sound, spanning ~170 km. We used trait and phylogenetic data to quantify diversity (phylogenetic, functional, and species diversity) and used a model selection approach to calculate which environmental variables were the best predictors for these indices across sites. Algal species richness emerged as an important environmental variable predicting variation across various diversity indices, appearing in nearly all of the best-supported models. Algal species richness was correlated with diversity of both herbivores and non-herbivores, suggesting it is important for habitat provisioning as well as a food source.

Session 24: Conservation and Restoration 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**LINKING CLIMATE AND SEED GERMINATION RATE FOR THE THREATENED CALIFORNIA BLACK WALNUT TREE (JUGLANS CALIFORNICA)** (YOUTUBE)
† Gonzalez-Smith, L.†; Lee, S; Willette, D.A.

*Biology, Loyola Marymount University*

Juglans californica is a foundational species of walnut woodland communities in Southern California, yet it is listed as threatened on the IUCN Red List due to pressures from urbanization and climate change. Successful seed germination of J. californica is believed to be tied to a cold-stratification period, yet the prevailing optimal temperature (5°C) is based on limited data from the middle of last century. First, we attempted to identify the optimal seed germination temperature for J. californica by screening a broad range of temperatures. Field-collected seeds were dehusked, imbibed for 24 hours, incubated at fixed temperatures (0°C, 5°C, 10°C, 15°C, 20°C) for 120 days (press treatment), and checked weekly for germination. Un-germinated seeds were further incubated at ambient air temperature for an additional 30 days. Germination rate was highest at warmer incubation temperatures, suggesting J. californica seeds may be resilient in a warmer future climate in Southern California. The next step is to uncover how short-term elevated temperatures affect germination. Climate change leads to more total hot days dispersed throughout the year. To better replicate this, J. californica seeds will be incubated at 15°C for four weeks, following an incubation of different temperatures (5°C, 10°C, 15°C, 20°C) for a week. This alternation will occur for a total of 14 weeks (seven weeks at ambient 15°C and seven weeks of altered temperature). This “pulse method” may further reveal how changes in climate effect the germination of J. californica seeds.

**A CASE FOR FURTHER RESEARCH OF THE CHUMASH MEDICINAL SYSTEM: PHYSIOLOGICAL, ECOLOGICAL, AND CULTURAL VALUE**
† Hayer, R.S.†; Willette, D.A.

*Biology, Loyola Marymount University*

The Chumash people have developed a complex and effective healing process over thousands of years, largely relying on the use of medicinal plants through the form of foods, teas, and incense. Increased use of these medicinal plants as homeopathic alternatives to prescription medicine presents a valuable opportunity to further physiological, ecological, and cultural research of the intricate and deeply significant healing system of the Chumash people. Despite noted efficacy in treating various ailments, in vivo physiological responses require further evaluation. From a group of 37 staple medicinal plants used in Chumash healing practices, only one (2.7% of the total) has been used in clinical trials. A review of literature was conducted, focusing on the biochemical composition and ecological importance of five native California plants: Salvia apiana, Rosa woodsii, Umbellularia. californica, Datura wrightii, and Salix lasiolepis. Data shows that biological
compounds associated with known the medicinal functions of each plant have been identified. Research also indicates strong overlap of medicinal value and ecological importance to Southern California ecosystems, and a rising threat to cultural appropriation. This review warrants further physiological investigation, but through proper channels as to not appropriate and harm both Southern California ecology and the Chumash/Native American populations whose cultures are deeply intertwined with healing.

**SPATIOTEMPORAL ANALYSIS OF IN SITU SEA TEMPERATURE ACROSS A MODEL MONTIPORA CAPITATA POPULATION IN KĀNE'OHE BAY, HAWAI'I**

Hobbs, C.J. *; Ruiz-Jones, L.; Caruso, C.

*affiliation not listed*

Coral reefs are threatened by numerous stressors, but thermal stress due to changing climate is the most severe. Rising ocean temperatures and local stressors lead to a breakdown of the coral-algal symbiosis, which is defined as a reduction in pigment content of the algae or a significant decrease in Symbiodiniaceae cells from host tissues. This can compromise the functioning and structure of reefs. The sustainability of coral reefs will depend on the continued severity of climate change, the extent of other environmental disturbances, and the ability of the coral holobiont to acclimatise and adapt. To understand the roles of adaptation and acclimatisation, it is imperative to characterise the conditions that different coral reefs experience. Kāne’ohe Bay is Hawai’i’s largest sheltered body of water within the main eight Hawaiian Islands, and is a spatially heterogenous mosaic, rendering it an ideal location to investigate the spatiotemporal variation of benthic sea temperature. We looked to gain an understanding of the different temperature profiles that colonies of *Montipora capitata*, a dominant reef-builder that may be suitable for restoration efforts, experience. Using temperature loggers, we characterised 30 sites over three years across the bay. We are investigating which sites experience similar thermal regimes through hierarchical clustering analysis and by examining daily profiles. We also seek to create a spatially interpolated map of degree heating weeks across the bay. Understanding the temperature variation across the bay can assist management efforts.

**GENETIC TESTING REVEALS MISTAKEN IDENTITY OF INTRODUCED SPECIES FOR ENDEMIC SPECIES IN BLACK WALNUT TREE RESTORATION**

† Lam, S.*; Horvath, A.; Willette, D.A.

*Biology, Loyola Marymount University*

Ecological restoration aims to enhance biodiversity and combat climate change. The urgency to restore, however, may overlook genetic considerations important for the long-term viability of the species. *Juglans californica* is a foundational species of Southern California. It is listed as Threatened on the IUCN Red List, therefore it is important to retain the genetic uniqueness of the species. A field survey and genetic testing of black walnut trees for seed sourcing in Los Angeles’ Ascot Hills Park revealed mistaken identification and potential hybridization between endemic Southern California Black Walnut (*Juglans californica*) and introduced Eastern Black Walnut (*J. nigra*). Morphological features and leaf samples were collected from 30 trees (~25% of all walnut trees present) within the park. The MatK and ITS4/5 chloroplast gene regions were amplified and sequenced to infer phylogenetic relationships among trees using maximum likelihood analysis. Results thus far suggest the presence of both species and highlight the need for further species validation prior to seed sourcing in restoration efforts. The next step will be to assess the diagnostic morphological features of leaves, leaflets and bark in a Bray-Curtis dissimilarity index and visualize them in a dendrogram for comparison.
Conserving California’s Seamounts (YOUTUBE)
Lance Morgan*; Samuel Georgian

Marine Conservation Institute

California’s offshore waters are home to a number of seamounts. These are massive underwater volcanoes that can support incredible levels of biodiversity. These extremely productive features serve as oases in the often sparsely populated deep sea, supporting high abundances of benthic and pelagic organisms including corals, sponges, anemones, crabs, fish, sharks, seabirds, turtles, whales, and dolphins. The waters off the coast of California house an estimated 63 seamounts. Of the few that have been explored, these habitats have been found to contain extensive deep-sea ecosystems teeming with life. The Californian seamounts stand poised at a critical conservation junction. With the advent of new technology and increasing commercial interest, a barrage of threats including fishing, oil and natural gas extraction, seafloor mining, pollution, and climate change endanger these fragile ecosystems. To date, only one seamount, Davidson, has been protected within marine protected areas. Here, we provide a general overview of the seamounts in California waters with a focus on their biology, sensitivity to anthropogenic threats, and conservation outlook.

METABARCODING ANALYSIS OF STOMACH CONTENTS IN TOTOABA MACDONALDI (YOUTUBE)
† Mroue-Ruiz, F.H.1*; Schramm-Urrutia, Y. 1; Pacheco-Sandoval, A. 2; Giffard-Mena, I. 1; Abadía-Cardoso, A. 1; Chong-Robles, J. 2; Lago-Lestón, A. 2

1- Universidad Autónoma de Baja California 2- Centro de Investigación Científica y de Educación Superior de Ensenada

Totoaba macdonaldi is an endangered fish species endemic from the Gulf of California. Due to overexploitation, the Mexican government banned the fishery in 1975. However, it is still illegally fished and exported to China because the gas bladder is highly valued in traditional Chinese medicine. Despite its status, little is known about Totoaba biology. In order to optimize Totoaba farming, and to include the knowledge about its trophic ecology in conservation efforts, the diet of this fish has to be well characterized. Therefore, the aim of this study was to standardize a metabarcoding protocol to describe the diet by next-generation sequencing. We dissected four wild Totoaba individuals that had been seized by Mexican law enforcement agents, and we collected the stomach contents. From extracted DNA, we generated four representative amplicon libraries for cephalopods, chordates, marine invertebrates, and eukaryotes. After sequencing, we identified 12 different prey indicating Totoaba’s preference for fish (9 species), mainly Pacific anchovy (Cetengraulis mysticetus) and Flathead grey mullet (Mugil cephalus). Other identified prey were members of the family Euphausiidae (krill). Compared with previous studies based on morphological recognition of prey in 35 stomachs, we identified more taxa and species (18 and 14 vs 15 and 3, respectively) in only 4 stomachs. Moreover, we found seven new prey species. Our work confirms that metabarcoding is an effective method to study the feeding habits of this species, providing the tools to further analyze Totoaba diet.

PERSPECTIVES ON PRIORITIES FOR SUPPORTING THE WELLBEING OF WEST COAST FISHING COMMUNITIES (YOUTUBE)
† Nelson, L.K.1*; Levin, P.S. 2; Bogeberg, M.A. 3; Strawn, A. 4; Koehn, L.E. 1; Cullen, A.C. 1


Climate-driven changes to the California Current Large Marine Ecosystem are likely to disrupt the economies and social fabric of fishing communities on the West Coast of the United States. These
impacts, as well as other environmental changes and economic pressures, are negatively impacting fishing community wellbeing. As mandated by National Standard 8 of the Magnuson-Stevens Act, fisheries managers must consider community impacts as they work to balance current harvest and the long-term sustainability of fisheries. However, the worldviews and values of managers may shape their perceptions with regards to the aspects of wellbeing they believe to be of the greatest benefit to fishing communities, and at the greatest risk. We employed Q methodology to explore perspectives of fisheries stakeholders and resource managers by having them rank statements that describe environmental, economic, or social conditions in terms of what they consider to be most important for fishing community wellbeing. Our analysis revealed three common perspectives held by participants that respectively centered collaboration in fisheries management, the adaptive capacity of fishers, and climate change as the highest priorities. The points of divergence and consensus in these perspectives provide an opportunity to discuss and reflect upon the role of fisheries management in supporting coastal community wellbeing.

**DOCUMENTING THE PRESENCE OF OSTREA LURIDA BEDS IN SOUTHERN CALIFORNIA BETWEEN THE LATE-1800’S TO THE EARLY-1900’S**

† Nguyen, J.K.; Zacherl, D.C.

*California State University, Fullerton*

Olympia oysters (*Ostrea lurida*) are the only oysters native to the United States west coast. A noticeable shift began in the late-1800’s to early-1900’s with Olympia oyster habitat and abundance significantly declining due primarily to overharvesting, coastal development, and pollution. We documented the historic presence and distribution of the native oysters along the southern California coast prior to their decline. We initially examined historic T-sheets to determine whether oyster reef or bed symbology was present; there did not appear to be clear symbology, so our research expanded to other sources. Through further analysis of historic primary literature, government publications, archaeological data, as well as newspaper articles, a comprehensive map revealing the locations and dates of the native oyster’s presence was created to document their historic distribution, with particular focus on documenting evidence of oyster bed habitat. Although the native oysters were present at many sites along the southern California coast during this time frame, the four focal areas of study include San Pedro Bay, Alamitos Bay, Newport Bay, and San Diego Bay. By creating a record of the native oyster’s historic distribution, we can begin to address the effects of a shifting baseline syndrome. Due to a contemporary lack of oyster bed habitat in these bays, we hypothesize that resource managers may place less emphasis on conserving this species and restoring historic habitat.

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

**INVESTIGATING REGIME SHIFTS IN NORTHWEST HAWAI’I ISLAND CORAL REEF SYSTEMS**

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*Seattle Aquarium and University of Washington School of Marine and Environmental Affairs*

The Northwest coast of the Big Island of Hawai’i was heavily impacted by the 2014-2017 global coral bleaching event, which was estimated to have altered 75% of coral reefs worldwide (Hughes et al., 2018). Consecutive bleaching events in 2014 and 2015 were observed at various sites along the coast. My thesis project aims to investigate regime shifts at eight sites along the West side of Hawai’i. How does fish community differ pre- and post-bleaching event and can this be correlated to
changing environmental variables? Video transect surveys were conducted annually (typically in January-February) from 2009-2020, and fish were counted and identified to 119 different species. A generalized linear model was developed to identify environmental drivers of regime shifts. Healthy nearshore reefs are vital for ecosystem services such as contributing to economy, food and cultural significance. Maintaining diversity and abundance of these systems is a priority to management, community members, and those who are invested in encouraging these systems to thrive. This project aims to inform the 30x30 conservation initiative, by identifying key environmental variables that influence changes in fish community structure along the Northwest coast of Hawai‘i.

**SUSTAINABILITY OF THE CALIFORNIA SPINY LOBSTER FISHERY: ASSESSING REGIONAL VARIABILITY IN LOBSTER REPRODUCTIVE POTENTIAL** *(YOUTUBE)*
Perun, A.C.*; Dunn, R.P.; Hovel, K.A.; Burnham, T.L.; Pollard, E.A.

*San Diego State University*

The California spiny lobster *Panulirus interruptus* supports valuable fisheries in California and Mexico. The State of California has implemented a lobster fishery management plan (FMP) to manage the lobster resource. Within the FMP, key reference points such as the spawning potential ratio (SPR) are monitored to determine whether management actions should be implemented to protect the health of the lobster fishery. SPR is a widely-used metric for assessing the health of a fished population, but its use requires an understanding of how reproductive potential varies with organism size. Presently, estimates for female fecundity-at-size and size-at-maturity, two key aspects of reproductive potential, come from < 30 individual California spiny lobsters caught prior to 1955. Moreover, little information exists on biogeographic variability in these parameters. We used trap-based and SCUBA-based sampling conducted across the Southern California Bight and Baja California to determine how lobster fecundity-at-size and size-at-maturity vary regionally, and whether estimates presently used in the lobster FMP are reasonable. We found biogeographic variability for both reproductive parameters. Size-specific fecundity increased from south to north, and maturity-at-size varied substantially among regions and was lower than estimates used in the FMP. Our results suggest that management of the spiny lobster resource should consider biogeographic variability in lobster biology, particularly in light of potential effects of climate change on the lobster population and fishery.

**ACCOUNTING FOR TRANSIENT DYNAMICS IMPROVES USE OF MARINE PROTECTED AREAS FOR FISHERIES MANAGEMENT** *(YOUTUBE)*
†Quennessen, V.I.*; White, J.W. 2

1- Department of Fisheries and Wildlife, Oregon State University 2- Department of Fisheries and Wildlife, Coastal Oregon Marine Experiment Station, Oregon State University

Fisheries management that is based on quantitative assessment relies on estimating the unfished biomass of a fished stock. Smaller, new, or mainly recreational fisheries may not have the data to estimate that value, but fully no-take marine protected areas, or reserves, can provide information as the population inside recovers. Ideally, the population density inside the reserve could serve as an 'unfished' reference point. However, it takes time for the population in a reserve to return to that unfished state, and during that recovery, transient population dynamics differ from their long-term, equilibrium patterns. We examined how fishery management using information from a reserve – i.e. the ratio of population densities outside to inside the reserve – could be improved with an age-structured, spatially-explicit computational model. In deterministic simulations, management strategies that accounted for short-term dynamics inside the reserve preserved greater biomass and greater fishery yield in the long run, though the optimal management strategy varied somewhat
among the four nearshore fish species modeled. However, the differences in performance between management strategies that did or did not account for short-term dynamics within reserves were less pronounced when simulations included sampling error and variability in larval recruitment. In general, accounting for the time lags associated with the recovery of populations inside reserves is an important consideration in the use of reserves as a fisheries management reference point.

**SUMMER SLIM DOWN WITHOUT THE PUSH-UPS: HOW OCEAN TEMPERATURE AND PRODUCTIVITY INFLUENCE ROCKFISH BODY CONDITION** (YOUTUBE)
† Rosemond, R.C.1*; Martin, K.B. 2; Arbuckle, N.S.M. 1; Heppell, S.A. 1

1 Department of Fisheries and Wildlife, Oregon State University 2 Department of Oceanography, University of Bordeaux, France

The California Current Ecosystem is highly dynamic, driven not only by natural climate oscillations and seasonal upwelling but also by anthropogenic, directional climate change. Extreme anomalous events such as marine heat waves are predicted to occur with increasing frequency and intensity. Our study investigates (1) how these ocean processes influence Black Rockfish (Sebastes melanops) body condition on interannual and seasonal scales and (2) potential time lags between environmental drivers and biological response. We collected muscle tissue samples from female Black Rockfish caught on recreational fishing charters off the central Oregon coast from June to October of 2015 to 2018. Body condition was quantified using proximate analysis as the proportion of fat in muscle tissue. Using generalized additive models in a hierarchical modeling framework, we predicted body condition response to sea surface temperature (SST; lagged 0-6 months), El Niño-Southern Oscillation (ENSO; seasonal and lagged 0-12 months), and coastal productivity associated with upwelling (lagged 0-6 months). Preliminary results suggest SST at time of capture drives a unimodal response in body condition, winter ENSO anomalies drive a negative linear response in body condition, and higher coastal nitrate flux moving through the food web drives a positive response in body condition five months later. The results of this study provide insight into a fitness-related response of Black Rockfish to environmental conditions that may be scaled up to population productivity under various climate change scenarios.

**SPECIES ON THE MOVE: ADAPTATIONS OF FISHING COMMUNITIES** (YOUTUBE)
Selden, B1*; Papaioannou, E 2; St. Martin, K 3

1 Wellesley College 2 GEOMAR Helmholtz Centre for Ocean Research Kiel 3 Rutgers University

Warming waters are driving species to shift their distributions poleward. As they do so, species are moving out of traditional fishing grounds and moving into others. Our research within fishing communities on the US East Coast reveals diverse adaptation strategies with some communities following fish while others shift the species they target. This talk will discuss key factors that constrain or facilitate those responses.

**ENERGY BUDGETS AND GROWTH OF LARVAL FISH IN A WARMING OCEAN: AN EXPERIMENTAL STUDY OF CALIFORNIA GRUNION, LEURESTHES TENUIS** (YOUTUBE)
† Shelley, C.E.*; Johnson, D.W.

California State University, Long Beach

Rising ocean temperatures have important consequences for growth of larval fish populations and observed relationships between temperature and growth are not consistent across fish species. The key to such variation is understanding how temperature affects the amount of energy available for growth. We evaluated multiple working hypotheses about the relationship between temperature
and larval fish growth by examining the underlying mechanisms of energy intake and expenditure. Larvae of California grunion (*Leuresthes tenuis*) were reared at temperatures ranging from 16°C to 28°C. Across this temperature range, energy intake was measured from feeding rate and energy expenditure was evaluated by measuring respiration rate. Both feeding rate and respiration rate increased with temperature, but feeding rate increased more rapidly with temperature. These results would suggest that high temperatures lead to a greater surplus of energy and greater rates of growth. However, our analyses of growth do not bear this out, as rates of growth actually exhibited a slight decline with temperature. Taken together, these results suggest that a larva’s ability to assimilate food may become much less efficient at high temperatures. Ongoing experiments evaluating the effects of temperature on waste production may shed light on the mechanisms by which assimilation efficiency is reduced at high temperatures. Overall, our study suggests that a detailed consideration of the bioenergetics underlying growth will be useful for understanding how growth rates are likely to change in a warming ocean.

**HOW THE TIMING OF LARVAL RECRUITMENT PULSES AFFECTS THE ADAPTIVE MANAGEMENT OF MARINE PROTECTED AREAS (YOUTUBE)**

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

1- Oregon State University 2- University of California Santa Barbara

The dynamics of many temperate reef species are characterized by periodic pulses of larval recruitment, followed by multiple years of low recruitment. In short-lived species this leads to swings in population abundance as cohorts age through the population. For populations inside a newly-created marine protected area (MPA), this means that how quickly abundances build up inside the MPA depends on how recently there has been a recruitment pulse. Using a twenty-year record of larval settlement of kelp bass (*Paralabrax clathratus*) in the Santa Barbara Channel, we show that recruitment pulses have a 6-8 year periodicity. Further, using a population model, we show that when the MPA happened to be implemented – relative to the most recent recruitment pulse – affects the probability of detecting an increase in population abundance 5-10 years later. Depending on that timing, the probability could range from 60% to 90%. Managers should account for this artifact of population dynamics when assessing MPAs at fixed time intervals, as California and Oregon do.

Session 26: Intertidal Ecology 3

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

**UNRAVELING THE DIVERSITY AND DISTRIBUTION OF RIBBON WORMS IN BODEGA BAY, CALIFORNIA (YOUTUBE)**

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

Coastal ecosystems face threats from interacting disturbances including habitat loss and climate change. Rapidly changing environments have created a critical need for baseline data of marine biodiversity to provide the foundation for future scientific monitoring. However, in California, the diversity and distribution of some taxa are still poorly known. Nemerteans (or ribbon worms) are a remarkable group of invertebrates that have received surprisingly little attention in California since the foundational work by Coe in the early 1900s. Recent molecular studies in Oregon suggest that only a fraction of the nemertean species in the Northeast Pacific have been described. Therefore, we performed a survey of nemertean diversity in the Bodega Marine Reserve and surrounding areas in
Bodega Bay, California. Our survey revealed ~45 species, only 14 of which had been recorded in prior historical surveys in this region. Our study revealed new range records and several undescribed species, and we are further investigating other specimens that do not seem to match current species descriptions. One of the undescribed species, Riserius sp. nov., occurs on coarse sandy beaches, and we report survey data regarding its distribution in relation to environmental conditions. Overall, our results will aid in the identification of nemerteans for future efforts to characterize marine biodiversity during an era of ongoing environmental change.

**Drivers of a broad-scale pattern in cyanobacterial erosion in Mytilus californianus** (YOUTUBE)

Gehman, A.-L. M.; Brownlee, G.; Schaeffer, O.; Harley, C.D.G.

1- Hakai Institute and University of British Columbia 2- University of British Columbia

Along the Pacific coast of North America, Mytilus californianus shells are consistently eroded by endolithic cyanobacteria in a gradient across the intertidal. We evaluated how host traits, parasite traits and their interaction act as drivers of this broad-scale pattern, with two field outplant experiments at four sites in British Columbia, Canada. We examine growth of the mussel and its shell-boring endolithic cyanobacteria and disentangle their confounded interactions with manipulative experiments. We evaluated the relative importance of each trait and its variation on driving erosion patterns with a simple deterministic model, parameterized with the range of trait values measured in the field. We found that mussel and cyanobacteria have opposing growth responses across the intertidal, with high mussel growth and low erosion rates in the lower intertidal, and vice versa in the upper intertidal. We found that outplanted mussel growth rates were not altered by recent intertidal location (i.e. intertidal collection site), or by an experimental manipulation of cyanobacterial erosion. We found that cyanobacterial erosion was higher on dead shell material, suggesting that living mussels are somehow reducing erosion rates. Our modeling results suggest that despite the close interaction between mussels and their shell-boring endoliths, the variation in erosion across the intertidal can be driven primarily by the lower limit and rate of cyanobacterial erosion. If broadly consistent, this relationship could be an explanation for the erosion patterns global consistency.

**POSITIVE EFFECTS OF THE INTRODUCED BALANUS GLANDULA ON THE NATIVE SIPHONARIA LESSONII IN THE HIGH INTERTIDAL OF ARGENTINA** (YOUTUBE)

Gottlieb, E.R.F; Gutiérrez, J.L.; Palomo, M.P.; Bagur, M.; Gonzalez, J.A.

1- Fulbright Research Program 2- Instituto de Geología de Costas y del Cuaternario (IGCyC), Universidad Nacional de Mar del Plata. Also: Grupo de Investigación y Educación en Temas Ambientales (GrIETA) 3- Laboratorio de Ecosistemas Costeros y Malacología. Museo Argentino de Ciencias Naturales Bernardino Rivadavia (MACN-CONICET) 4- Centro Austral de Investigaciones Científicas (CADIC-CONICET)

Limpets use substrate roughness elements (i.e. crevices, sessile organisms) as resting sites during inactivity. Introduced barnacles, Balanus glandula, account for much of the roughness in high rocky intertidal zones of Argentina. We evaluate if introduced barnacles have a direct positive effect on densities of a native limpet, Siphonaria lessonii, and a positive effect on algal growth thereby indirectly affecting limpet densities. Limpet densities were positively related to barnacle densities in 11 out of 19 sites surveyed in Buenos Aires, Rio Negro, and Chubut Provinces. Non-significant positive relationships were found at sites with relatively low limpet densities and/or rough basal substrate. A high proportion (40.18% - 94.25%) of limpets at each site were adjacent to barnacles. Limpets positively responded to the addition of epoxy barnacle mimics into barnacle-free areas. Barnacle removal, with limpet exclusion, led to decreased algal growth. Surveys and experiments in
Tierra del Fuego Province revealed similar patterns between two species of *Siphonaria* (*S. lessonii* and *S. lateralis*) and a native barnacle (*Notochthamalus scabrosus*). Barnacles increase surface roughness in the high intertidal, providing refuge for limpets. Barnacles may confer shade, temperature control, and increased surface moisture. Increased surface area from barnacles increases algal biomass, indirectly driving the positive relationship between barnacle and limpet densities - limpets graze on algae. Consequent increase of limpet density in barnacle dense areas decreases algal biomass.

**IT'S A TRAP: HOW DASYSIPHONIA JAPONICA ALTERS THE GROWTH, SETTLEMENT, AND SURVIVORSHIP OF MYTILUS EDULIS.** *(YOUTUBE)*

† Hannibal, K.N.; Dudgeon, S.R

*California State University, Northridge*

The blue mussel, *Mytilus edulis* L., is an ecologically and economically important species that enhances biodiversity through both the modification and stabilization of its habitat. Widely attributed to OA, warming, and predation, mussels are disappearing from their native range in the Gulf of Maine (GOM). However, a documented 16% annual decline in recruitment indicates a notable decrease during early life stages. Interactions with invasive algal species may be an impetus for larval *M. edulis* loss, but such interactions are poorly characterized. *M. edulis* recruits often settle initially on filamentous macroalgae. They are known to occur in the interstitial space provided among branches of *Dasysiphonia japonica* (Yendo) H.-S. Kim, an invasive alga that has spread throughout the GOM since 2010. We hypothesized that *D. japonica* has a direct negative effect on the growth and survivorship of *M. edulis* that settle on it. We conducted an *in situ* settlement experiment in Nahant, MA to test the effect *D. japonica* has on *M. edulis* growth and survivorship. Results suggest that *M. edulis* does not settle within *D. japonica* at a significantly higher rate, when compared to those settled within filamentous control groups. However, *M. edulis* settled within *D. japonica* experienced lower mortality and slower growth over a five week period when compared to the control. Due to this, *M. edulis* settled within *D. japonica* will be vulnerable to predation longer as they settle into coastal beds, thus impacting the health and size of beds throughout the GOM.

**NEW (INTERTIDAL) ZONE, WHO DIS? THE DIFFERENTIAL EFFECTS OF A HABITAT-FORMING ACORN BARNACLE IN ITS NATIVE AND INVADED RANGE** *(YOUTUBE)*

† Hesketh, A.V. 1*; Schwindt, E. 2*; Harley, C.D.G. 1

1- Department of Zoology, University of British Columbia 2- Grupo de Ecología en Ambientes Costeros, IBIOMAR-CONICET

Invasive species are often studied for the disproportionately strong negative effects they have on species in their invaded range. Less attention has been paid to whether invaders that are important facilitators in their native range can have persistent positive effects where they invade. In this study, we manipulated the density of the high intertidal acorn barnacle *Balanus glandula* in its native (Bluestone Point, British Columbia, Canada) and invaded range (Punta Ameghino, Chubut Province, Argentina) in combination with herbivore density to determine how this facilitator differentially affects associated species at these two sites. Given that high intertidal species at Punta Ameghino (PA) are evolutionarily naïve to barnacles, we expected the positive effects of *B. glandula* at Bluestone Point (BP) to be weakened or absent at PA. *B. glandula* had a positive association with perennial algal cover at BP, but a negative association with perennial algal cover at PA. Ephemeral algal cover at BP was negatively associated with barnacle cover, but the same association was positive at PA. Herbivore abundance, meanwhile, was positively correlated with barnacle cover in both systems, and the strength of this interaction was similar in both the native and invaded range.
These results suggest that shared evolutionary history is not a prerequisite for species to benefit from a novel facilitator, and further reinforce the importance of the traits of associated species and environmental stress in governing the strength of facilitative interactions.

INDIVIDUAL AND ECOLOGICAL CONSEQUENCES FOR AN INTERTIDAL ROCKWEED TO CONDITIONS ASSOCIATED WITH SEA LEVEL RISE
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*California State University, Fullerton

Organisms in the intertidal zone, which experience terrestrial conditions during low tide emersion and are submerged in seawater during high tide, are threatened by sea level rise (SLR) which could reduce annual emersion time by over 50% over the next 100 years. Using a manipulative field experiment, we tested the hypothesis that SLR conditions would negatively impact performance of individuals of the canopy-forming seaweed Pelvetiopsis californica. At two southern California sites, we established three treatments: marked in place individuals (transplant controls: MP) were not moved; middle-zone transplant individuals (MT) were relocated at the same tidal elevation; and below-zone transplant individuals (BT) were moved to a lower tidal elevation, exposing them to shorter emersion times (= SLR conditions). We assessed health through monthly measurements of size, cover of epiphytic seaweeds (which grow on the host, blocking light and nutrients), and reproductive potential. In two eight-month replications, we saw lower performance in the SLR condition treatment (BT) than in non-SLR treatments. BT individuals lost more tissue (on average, 25% of their original length) than individuals in other treatments. More than three times as many individuals in the BT treatment were infected with epiphytic seaweeds than in MT or MP treatments. These data indicate substantial risk of SLR to seaweed populations and may help managers develop mitigation efforts for this important intertidal producer.

HUMAN MODIFICATION OF LAND-SEA NUTRIENT INPUTS ALONG A COASTAL MEDITERRANEAN ECOTONE (YOUTUBE)
† Hill, R. J.*; Bracken, M. E. S.

*Ecology & Evolutionary Biology, University of California, Irvine

Increases in coastal urbanization have introduced novel nutrient inputs to rocky intertidal ecosystems, especially in drier areas like Southern California. Storm runoff provides seasonal fluxes of nutrients, but coastal neighborhoods now contribute nutrients – associated with fertilizer application and irrigation – via runoff year-round. This runoff comes from storm drains, artificial channels, historical watersheds, and directly from homes. We evaluated how excess nutrients from runoff affected the biodiversity of rocky intertidal pools along the coast of Orange County, CA. Weekly samples were taken from tidepools and storm drains along the beach, and additional sampling was conducted during rainfall events. Water samples were collected from drainages and adjacent tidepools to determine nitrate, phosphate, and ammonium concentrations. Samples of the seaweed Ulva lactuca were collected from tidepools to determine internal %C, %N, and C:N ratios. We also conducted mobile invertebrate surveys in each tidepool. Tidepools closest to runoff sources were characterized by higher concentrations of nutrients compared to those farther away. The %N of Ulva lactuca increased with high nitrate concentration in the drain areas. Pools that received regular input from storm drains had significantly higher numbers of Tegula, limpets, and chitons. Transitioning from seasonal rain-mediated runoff to year-round human-modified nutrient inputs from coastal neighborhoods has changed the nutrient cycling and biodiversity of this Southern California rocky intertidal ecosystem.
SPIES IN THE TIDES: APPLICATION OF NOVEL TECHNOLOGY FOR MONITORING CARDIAC ACTIVITY IN BIVALVES (YOUTUBE)
† Kalbach, G.M.; Miller, L.P.

San Diego State University

Organisms living in rocky intertidal habitats face a multitude of stressors from both marine and terrestrial climates as a result of tidal cycles. Warm air temperatures combined with daytime low tides exacerbate desiccation and thermal stress for intertidal invertebrates and have been shown to cause mass die offs in bivalves and other taxa. Most intertidal inhabitants already live on the cusp of their thermal tolerance limit, so even slight increases in average and maximum temperatures can have negative effects on physiology and therefore impact the distribution and abundance of species. A well-documented metric for determining physiological response to stress is heart rate. To monitor the thermal stress response of a common intertidal species, 16 Mytilus trossulus individuals in the field were fitted with infrared heart rate sensors in summer 2020 to continuously monitor heart rate non-invasively. Comparisons were made between individuals that were submerged in tide pools throughout the tidal cycle and individuals that were exposed to air during low tides. We tracked individual temperature and heart rate across multiple days to look for differences in individual responses to varying environmental conditions over small spatial scales. Identifying the thermal stress response of intertidal species allows for predictions of future die offs and can inform management decisions regarding vulnerable intertidal communities.

Session 27: Reproduction, Dispersal, and Recruitment 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

RECRUITMENT OF THE SEA URCHIN PARACENTROTUS LIVIDUS ALONG THE CENTRAL COAST OF PORTUGAL (NE ATLANTIC OCEAN) (YOUTUBE)
Maresca,F.1*; Jacinto, D. 1; Mateus, D. 1; Alves, C. 1; Castro, J.J. 1; Costa, J.L. 2; Cruz, T. 1

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The rock-burrowing sea urchin Paracentrotus lividus is a common echinoid species that inhabits shallow temperate shores and is an important ecological and economical resource in Atlantic and Mediterranean coastal habitats. P. lividus distribution patterns are highly variable at different spatial and temporal scales and influenced by different biological and physical processes. Recruitment to the benthos is an important process in regulating sea urchin abundance. Recruitment patterns of this species are not fully investigated in the NE Atlantic Ocean and its knowledge could have implications on the sustainability of harvesting of the resource. Our work aims at studying the temporal and spatial variability in recruitment patterns of P. lividus in shallow subtidal rocky bottoms (<2m depth). In order to estimate recruitment variability, every month of 2020 we deploy artificial collectors (20x6cm scrub brushes; n=5) in a total of six sites, appropriately spaced to provide recruitment variability in two different spatial scales, tens of kilometres and hundreds of meters. On average, 4 recruits collector^-1 were found (from 0 to 52 recruits), which started to appear in April and their abundance has been increased as summer months approach. Their test diameter ranged from 0.34mm to 5.51mm. Trends show a remarkable variability in both of the spatial scales. These results, coupled with broader knowledge of the ecology of P. lividus, are needed for a better understanding of its life stages, which is required for long term sustainability of the resource.
METHODOLOGY FOR DISTINGUISHING ADULT PYCNOPODIA HELIANTHOIDES BY COLOR PATTERN (YOUTUBE)
Pearson-Lund, A.S.*; Kitaeff, P.; Hodin, J.

University of Washington

In 2013, a deadly syndrome known as seastar wasting disease emerged and swept through the NE Pacific affecting almost every species of asteroid and leading to massive declines in populations. Almost a decade later, many species have not fully recovered. One such species, the sunflower star Pycnopodia helianthoides, may now be completely absent from California. The once common P. helianthoides is a known predator of the purple sea urchin (Strongylocentrotus purpuratus) and the disappearance of this star has coincided with an increase in these urchins as well as a startling decrease in bull kelp (Nereocystis luetkeana) in Northern California. This suggests the predatory pressures of the sea star may help maintain the balance of the kelp forest ecosystem. In order to investigate their life cycle and facilitate their possible return to the wild, we have initiated a captive rearing program at Friday Harbor Labs in the Salish Sea, where there are remnant populations of P. helianthoides. This program includes a breeding colony of stars that we have maintained for over a year, monitoring their reproduction, and spawning a subset for successful rearing of embryos and larva to juvenile stages. The ability to distinguish between adults in the breeding colony is crucial to track experimental procedures performed, such as hormone injection, gamete collection, and larval lineage. Here, we will discuss a variety of methods we have established to positively identify individual adult stars in our breeding colony.

IMPACTS OF AN INVASIVE ALGA ON THE RECRUITMENT OF A TEMPERATE REEF FISH (YOUTUBE)
† Rosenblatt, S.E.*; Anderson, T.W.

Coastal & Marine Institute, San Diego State University

As the invasive alga Sargassum horneri continues to spread along the coast of southern California, little is known as to how this invasive species may impact fish assemblages on native Macrocystis pyrifera-dominated reefs. Recruitment of many algal-associated fishes depends on M. pyrifera as habitat, and it is unclear how recruitment processes may be altered by replacement of M. pyrifera by S. horneri as biogenic habitat structure. Through a series of laboratory experiments, we investigated post-settlement processes related to recruitment success of a macrophyte- associated fish, Heterostichus rostratus (giant kelpfish). Using both S. horneri and M. pyrifera as treatments, we explored differences in (1) habitat choice by recruits in the presence of both macroalgae, (2) prey choice by recruits in feeding on mysid shrimp that were fed the two macroalgae, and (3) predator-mediated mortality of recruits in these two macroalgal habits by a common piscivore. Our experiments addressing these post-settlement processes suggest that S. horneri does not have a significant impact on this fish vs. M. pyrifera. Recruitment success of H. rostratus in S. horneri may be equivalent to that in M. pyrifera, although differential settlement to these macroalgae or other factors may play a role.

THE EFFECT OF COPPER ANTIFOULANTS ON LARVAL SETTLEMENT PREFERENCE IN TWO CRYPTIC INVASIVE BRYOZOAN SPECIES (WATERSIPORA) (YOUTUBE)
† Strawhand,A.K.*; Craig,S.F.

Humboldt State University

One of the largest threats to natural marine biodiversity is the introduction and successful establishment of invasive species. An invasive bryozoan, Watersipora subtorquata and its congener Watersipora ‘new species’ are thought to show an elevated resistance to copper paint, the most
widely used marine antifoulant biocide in use today. As a species with little ability to prevent settlers on itself, this may present an opportunity for “hitchhiking” of other invasive species not as tolerant of elevated copper levels. A further question beyond copper tolerance is whether the lecithotrophic larvae in these two species actively seek out and choose copper inundated surfaces over other “clean” surfaces. In this study we collected colonies of these two species from five sites within California ranging from Santa Cruz to Crescent City. Larval release was accomplished using a standard light induction method and fifteen larvae from each mother colony were pipetted into a three inch diameter PVC tube whose bottom was a polyester film painted in a bullseye pattern with four treatments; high copper, low copper, copper-free paint and unpainted polyester. Most larvae settled within 6 hours and average larval settlement per site ranged anywhere from 60% to 80% on copper surfaces vs 20 to 40% on non-copper surfaces. These results suggest a strong preference within larvae of these two species towards copper-based antifoulant surfaces, which may help explain their nearly ubiquitous global distribution in ports.

**SPAWNING, EMBRYOGENESIS, POLYEMBRYONY, AND SETTLEMENT OF AN OCTOCORAL (YOUTUBE)**

Tonra, K.J.*, Lasker, H.R. 2; Wells, C.D. 2

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

Understanding ontogeny and reproductive biology of reef-building organisms is necessary as ocean conditions change. This is especially true for octocorals on Caribbean reefs, which seem to be more resilient to long-term environmental change than scleractinian corals while providing some of the same ecological services. To better understand spawning, development, and settlement in gorgonians, we observed the black sea rod *Plexaura homomalla*, a common octocoral on shallow Caribbean reefs, from eggs to 3-polyp colonies over the course of 73 days. Gametes were collected from colonies maintained in sea tables on St. John, USVI during spawning events after sunset, three to six days after the July full moon. Cleavage started 3 hours after fertilization and was holoblastic, equal, and radial. Embryos were slightly buoyant until becoming planulae three days after fertilization. Planulae were competent to settle four days after fertilization. Polyps began to show visible densities of Symbiodiniaceae approximately eight days after fertilization, when the tips of their tentacles began to turn brown. Development was typical for Caribbean octocorals except for an increase in the number of embryos between 3.5 and 6 hours after fertilization. This increase suggests the occurrence of polyembryony, a process previously undescribed in octocorals, by which a single embryo splits into multiple after fertilization. This process may contribute to the relative success of some octocorals in the Caribbean, and further research should be done on the causes and consequences of embryo fragmentation.

**DIRECT RELEASE OF EMBRYONIC SPOROPHYTES FROM ADULT NEREOCYSTIS LUETKEANA IN A HIGH LATITUDE ESTUARY**

Ulaski, B.P.*

*College of Fisheries and Ocean Sciences, University of Alaska Fairbanks*

Kelp have life history pathways that alternate between macroscopic sporophytes producing spores and microscopic gametophytes producing gametes. Occasionally, an alternate pathway is seen. This study examined the circumstances by which the high latitude estuarine bull kelp, *Nereocystis luetkeana* forego the free-living microscopic stages by releasing embryonic sporophytes directly from adult sori. To address this, sori were collected from reproductive adult sporophytes in Kachemak Bay, Alaska during the summers of 2018 and 2020. Inspection of propagules released from sori after the 48-hour spore release incubations indicated that viable spores were released
alongside, in some cases, embryonic sporophytes. It was not evident that the release of embryonic sporophytes followed spatial or temporal patterns. The percent of propagules that were embryonic sporophytes were not significantly different between attached and drifting individuals, nor were they different between first generation and overwintered adults. Nevertheless, the characteristic of directly releasing embryonic sporophytes from adult sporophytes might have ecological advantages for \textit{N. luetkeana}.

\textbf{WELCOME TO THE (TURF) JUNGLE: INCREASED MORTALITY OF OCTOCORAL RECRUITS IN TURF (\text{YOUTUBE})}

Wells, C.D.\textsuperscript{1*}; Martínez-Quintana, Á \textsuperscript{2}; Tonra, K.J. \textsuperscript{3}; Lasker, H.R. \textsuperscript{4}

1- Department of Geology, University at Buffalo, State University of New York, Buffalo, NY 2- Department of Environment and Sustainability, State University of New York at Buffalo, Buffalo, NY 3- Department of Geology, University at Buffalo, State University of New York, Buffalo, NY and Department of Integrative Biology, Oregon State University, Corvallis, OR 4- Department of Geology, University at Buffalo, State University of New York, Buffalo, NY and Department of Environment and Sustainability, State University of New York at Buffalo, Buffalo, NY

Algal cover has increased and scleractinian coral cover has steadily declined over the past 40 years on Caribbean coral reefs, while octocoral abundance has increased at sites where abundances have been monitored. The effects of algal cover on recruitment may be a key component in these patterns, as upright octocoral recruits may escape competition with algae by growing above the ubiquitous algal turfs. We used laboratory and field recruitment experiments to examine impacts of algal turf on recruitment of the common, upright, and zooxanthellate Caribbean octocoral \textit{Plexaura homomalla}. Laboratory recruitment rate was significantly higher in lower turf cover treatments. Field survival was significantly reduced by increased turf cover; for every 1% increase in turf cover, polyps died 1.3% faster. In a model parameterized by the observed field survival, polyps exposed to 100% turf cover had a 2% survival rate over 51 days, while polyps exposed to no turf cover had a 32% survival rate over the same time. We found that high densities of turf algae can significantly inhibit recruitment of octocorals. Octocoral survival rates were similar to those published for scleractinians, but field recruitment rates were much higher, which likely contributes to the higher resilience of octocorals to disturbances. The factors that influence recruitment are critical in understanding the dynamics of octocorals on Caribbean reefs as continuing declines in scleractinian cover may lead to more octocoral-dominated communities in the Caribbean.

\textbf{INVESTIGATING THE EFFECTS OF COASTAL STRESSORS ON THE CONNECTIVITY OF OYSTER POPULATIONS IN NARRAGANSETT BAY (\text{YOUTUBE})}

Zyck, A.H.\textsuperscript{1*}; Stevick, R. \textsuperscript{2}; Padro, N. \textsuperscript{1}; Gallagher, A. \textsuperscript{3}; Gomez-Chiarri, M. \textsuperscript{2}; Puritz, J. \textsuperscript{1}

1- University of Rhode Island, Department of Biological Sciences, Kingstown, RI 02881 2- University of Rhode Island, Department of Fisheries, Animal and Veterinary Sciences, Kingstown, RI 02881 3- University of Rhode Island, Marine Biology Program, Kingstown, RI

Coastal urban areas are a major source of marine pollution in coastal environments, discharging sewage effluent (SE) via wastewater treatment facilities. Sewage effluent is one of the largest inputs of nutrients into coastal ecosystems, driving primary production. The subsequent microbial respiration results in increased coastal acidification (CA). Both SE and CA are known to negatively affect the survival and development of important coastal species, like the Eastern oyster, \textit{Crassostrea virginica}. Oysters have a sessile adult stage with low dispersal potential making them dependent on their pelagic larval stage for long-distance dispersal to increase gene flow across populations. Larvae are more sensitive than adults to a variety of natural and anthropogenic
stressors making them a natural conduit for adaptation to environmental stressors. SE and CA may act as barriers to gene flow, limiting larval exchange by selective mortality (only letting resistant larvae pass), structuring populations through reduced connectivity. To investigate the effects of SE and CA on the connectivity and genomic diversity of oyster populations, adult oysters were collected from 4 sites in Narragansett Bay varying in environmental conditions and distance from SE sources. Sequence capture probes were generated from mRNA extracted from larval oysters exposed to treatments of CA and SE. These probes were used to capture regions of the adult genome highly expressed in response to these stressors. Seascape genomics analyses will identify population with higher resistant genotypes and relate allele

Session 28: Special Session: Tidepooling with John: In honour of Dr. John Pearse
* indicates presenting author, † indicates eligibility for Best Student Paper Award

Introduction to the symposium (YOUTUBE)
Estes, J.A.*

University of California, Santa Cruz

John Pearse was giant. In introducing this symposium, I will briefly recount his history and reflect on the qualities that resulted in him making an indelible mark on the lives of so many.

The benevolence of John Pearse (YOUTUBE)
Lindberg, D. R.*

UC Berkeley

Most of us knew John in compartmentalized units of time and topic. Kelp forest work in the 1970s, photoperiodism in the late 70s and early 1980s, return to Antarctic research in the late 1980s, Cal Academy governance in the late 1990s and early 2000s, LiMPETS for over 20 years after his retirement, etc. – the categories are numerous, diverse, and unique. While separate timeline events for us, the compartments were all connected by John’s intellect and he used this integration to gain insights into the many diverse topics and questions that fascinated him. These compartments also shared John’s benevolence which we all experienced and greatly benefited from, and which extends far beyond John himself.

JOHN PEARSE: HIS UCSC LEGACY
Costa, D.P.*

UCSC

While at UCSC he was instrumental in establishing the marine science program and was a critical player in the Institute of Marine Sciences. He was the first faculty member to develop a research program at the Long Marine Laboratory, which he continued after his retirement. He pioneered, combining teaching and research. His course Intertidal Biology followed the changes in the intertidal after the closure of a nearshore sewage outfall. In his Kelp Forest Ecology course, John developed a long-term study of the animals in the Pt Cabrillo kelp forest off Hopkins Marine Station. He taught students the science of marine ecology, as they helped him collect data on marine organisms. Many of these students now enjoy careers in Science.

Natural History and Shifting Baselines along the Monterey Bay Shore: Contemplations with John Pearse
Carlton, J. T.*
Williams College

John Pearse carefully watched and studied the diversity of Monterey Bay's intertidal and subtidal habitats for 60 years. I share some of John's thoughts on the changing patterns and processes of species distributions since the mid-20th century.

**JOHN PEARSE REVEALED HOW TO SEE AND RESPECT THE NATURAL WORLD FROM TIDEPOOL UNIVERSES TO RAT-TAILED MAGGOTS**
Walker, S.E.*

affiliation not listed

John Pearse was a force of nature and like other great teachers at UCSC, changed my life forever. John and Todd Newberry's invertebrate zoology class was pivotal. Their mantra: The animal is always right! With incredible drawings of invertebrate innards, talking about philosophy and evolution, the most profound question they asked was: Why? Why was never an option in my previous scholastic experience. Tirelessly, they led us on field trips to tide pools from Carmel Point to Natural Bridges. The first tide pool was the hardest: What was I supposed to look at? John came over and reeled off an enthusiastic play-by-play, “Look at that, a peanut worm is feeding and wow, I wonder why Anthopleura is doing that?” then he quickly disappeared, leaving me stunned; but that was all it took to be hooked. On campus, we explored redwood stump pools where John plunged his entire arm into dank, putrid water and pulled up what looked like a shriveled dead animal: “Rat-tailed Maggot” he calmly explained as we all recoiled in horror. Senior thesis followed, plus co-teaching a university class, co-leading the Shedd Aquarium, and many other experiences. However, a woman counselor told me that women can’t be marine biologists. Sobbing, I burst into John’s office; he carefully explained where she was coming from and told me to follow my dreams and never give up. And here I am. Thank you, John, we’ll see you at the Great Tide Pool at 4 AM, and we’ll bring Ferrell’s donuts!

**REMEMBERING JOHN: KELP FORESTS, LARVAE, CONSERVATION AND SAUNAS**
Steinberg, P.D.*

UNSW Sydney

I first met John over 40 years ago as a graduate student at UC Santa Cruz, where he was a mentor and member of my committee. He was instrumental in introducing me to the Californian coast and in teaching me about marine systems and approaches that have been core to my work as a scientist ever since – kelp ecology, larval settlement and conservation of marine environments. But the thing that I most remember and treasure about John was the sheer joy and profound appreciation that he had for all aspects of the natural world.

**SLIME TRAILS THROUGH THE TIDE POOLS: NUDIBRANCHS AND CLIMATE CHANGE**
Gosliner, Terrence M.*

California Academy of Sciences

John Pearse played an integral role in a collaborative team using nudibranch diversity patterns and historical distributions to document short-term and long-term shifts in population structure, trophic interactions and northern extensions of range. Leveraging historical data from citizen scientists beginning in the 1960s, intertidal surveys forty years later documented major changes in species composition, richness and distributional limits. John had a unique ability to recognize the key role citizen scientists play in documenting marine biodiversity and was an ardent supporter of
the critical importance of historical data in measuring change. That reverence and enthusiasm for discovery of new insights and sharing them with others was pervasive in John’s character.

THE PURSUIT OF TRUTH IN THE COMPANY OF FRIENDS: THE LEGACY OF JOHN PEARSE
(YOUTUBE)

Grosberg, R. K.*

Coastal & Marine Sciences Institute, UC Davis

When I started UCSC in 1972, I was an utterly clueless, 18-year-old neophyte. I was inspired to attend Santa Cruz by the Cowell College motto ("The pursuit of truth in the company of friends"), but had no idea what it embodied. And then along came John, the greatest teacher of the many great teachers I’ve been so fortunate to know in my life. More than any of them, John epitomized the eloquence of that motto in everything that he did. He was a fearless pursuer of the truth, inspiring us all to do the same, often through his own actions and thrill of discovery (or mere recognition that something was still true). But for me, John was bold enough to tell me the truth about myself, and in so doing, made me a far better person than I deserved, and inspired me to be a teacher myself. If you don't believe it, here's what he wrote in his evaluation of me for the Bodega Marine Lab spring course in 1974: "Rick was a bright, hard-working and active student in this course; he also learned the value of taking seriously advice from others during this course." Vintage John. And, well, sort of. But thank you, John, for your inspirational and breathtaking joy in the truth, and its eternal pursuit.

JSP’S CONTRIBUTIONS TO OUR UNDERSTANDING OF ANTARCTIC BENTHIC INVERTEBRATE REPRODUCTION
(YOUTUBE)

Isidro Bosch*

State University of New York at Geneseo

In 1961, when a young John Pearse arrived in McMurdo Station, Ross Sea, Antarctic invertebrates were generally considered to have continuous (aseasonal) patterns of reproduction and brood-protected development. His now classic work on the gametogenesis and development of the sea star Odontaster validus, the sea urchin Sterechinus neumayeri and other invertebrates established that, contrary to expectations, many Antarctic species had seasonal planktotrophic development and long-lived larvae. Planktotrophic and non-feeding dispersive larvae are now well documented in the Antarctic plankton, while brood protection seems to have evolved primarily in species rich clades of echinoderms and other invertebrates along the Scotia Arc and isolated sub-Antarctic Islands. These important findings raised new questions about larval survival and evolution of development in the cold, seasonally oligotrophic polar regions that continue to engross researchers today.

EXPERIENCES WITH JOHN PEARSE: TEACHING KELP FOREST ECOLOGY AND RESEARCH IN ANTARCTICA
(YOUTUBE)

Basch, L.V.*

University of Oregon, Oregon institute of Marine Biology

I’ll briefly reminisce about teaching with John in central California kelp forests and our work together in Antarctica and Santa Cruz on reproduction, larval ecology, and feeding.

PEARSE PASSION PAVES WAY FOR ANTARCTIC PROTECTIONS
(YOUTUBE)

Lockhart, S.J.*

Southern Benthics
John possessed a passion for his students but also a frustration with a rigid academic system that saw too many students, with a deep passion for science of their own, fall out of that system. He mourned their loss to science. When I struggled to fit a traditional science career into family life, John’s words and passion gave me the courage to forge a new and unbeaten path, particularly for a female scientist. Now I fight to protect the Antarctica we both loved.

**JOHN PEARSE: A PEOPLE CONNECTOR** *(YOUTUBE)*

Wright, W.*

_Schmid College of Science and Technology_

NA

**John Pearse’s Focus on Reproductive Biology** *(YOUTUBE)*

Cameron, R. Andrew*

_California Institute of Technology_

From the Red Sea to Central California by way of Antarctica, John Pearse’s work on reproduction of marine invertebrates has circled the world. In that voyage he has brought many of us along and done so with humor, excitement and deep insight. I first met John when he came to Santa Cruz to join the faculty in biology there. Our interest in echinoderms overlapped and we spent many pleasant moments puzzling over mechanisms controlling reproduction. Two key observations he gave us were the lunar control of reproduction in diadematid sea urchins and the role of day length in purple sea urchin reproduction.

**Back to Galileo: The academic ancestry of John Pearse shared by his academic descendants** *(YOUTUBE)*

Hood, N.Z*; Eernisse, D.J; Lindberg, D.R; Simison, W.B

**affiliation not listed**

Back to Galileo: The academic ancestry of John Pearse shared by his academic descendants

N.Z. Hood, D.J. Eernisse, D.R. Lindberg, and W.B. Simison

Tracing academic lineages can partly reveal the influences that led to a noteworthy scientist such as John Pearse, who was well known to have broad interests in zoology and natural history. Because the many students of Professor Pearse, and their students, etc., have naturally inherited this same academic genealogy, we thought it would be worthwhile to document these lines of descent. The results revealed that his academic ancestors trace back to distinguished European scientists after relatively few generations, and most of these scientists were outside the English-speaking scientific community. John, himself, had international research interests, working not only in California but also in Egypt, Antarctica, and while traveling around the world with his family. Probably the most striking result is that his academic heritage leads directly back to Galileo Galilei. In fact, the lineage leading to John Pearse and his students include many notable scientists and we will briefly review selected of their accomplishments, most of whom were well known enough to have detailed biographies online. It is our hope that this compilation will lead to further study of the master naturalist and his influences.

**The Pearse Effect: Educating Through Passion and Experience** *(YOUTUBE)*

Shannon E. Lee†*; Damhnait McHugh ²; Allison Gong ³; Frank Anderson ⁴
From 1971 to 1994 John Pearse was a faculty member at UCSC. During that time he taught a range of courses and reached thousands of biology students. His deep passion and unflagging enthusiasm were contagious in the lecture hall, the laboratory, and in the field. Perhaps most memorably, in upper-division field-intensive courses John guided students in their immersion in marine habitats in ways that helped them to understand the organisms in situ and to celebrate the diversity of the natural world. Those of us fortunate to have spent time with him in those courses, and then go on to be teachers ourselves, constantly hear his voice in our heads and his phrases trip off our tongues.

As teachers, we strive to share John’s knowledge and passion with our own students. From John, we learned how to foster curiosity and wonder about the natural world, and how powerful it is to be with students on the shore. Some of our fondest teaching moments are when John met our own classes in the intertidal where, in his captivating and unassuming way, he helped our students get to know the organisms and understand why we need to preserve their habitats.

John’s influence on his students was immense, and we like to think that his reach as a teacher goes much farther. The Pearse Effect is powerful—it lives on in his students, in our students, and beyond. We will share our experiences as students of John and as teachers who try to emulate his extraordinary ability to inspire students about all things spineless and marine.

IN THE SPIRIT OF JOHN: SHARING WONDER, DOING SCIENCE, AND BUILDING COMMUNITY IN THE TIDEPOOLS (YOUTUBE)
Young, A.N.*; Johnson, R.F.

California Academy of Sciences

Not only an incredible scientist and educator, John Pearse was also a dedicated naturalist who shared his love of the tidepools and its denizens with thousands of people. From field studies with his undergraduate students to developing the LiMPETS project for middle-, high-, and college-aged students, John always gave his knowledge freely and strove to foster scientific curiosity in others. John believed and demonstrated that one could do good science, share joy and have fun in nature, all at the same time. As two people both inspired by John, in designing our rocky intertidal citizen/community science programs, we wanted to (re)ignite a sense of wonder in participants, through focusing on careful observation and exploration, connection to place, and building communities of people who can learn from each other - while also collecting data to inform monitoring and management. Through building this corp of coastal naturalists in California we've been able to document species range changes, effects of El Niño, and mortality events, among other phenomena. Plus, when you have lots of people exploring the intertidal and documenting what they're seeing, you're bound to find things you weren't expecting! This talk will tell some “tales from the tidepools,” highlighting our volunteers, our programs, and some of the more interesting observations and events, all with the spirit of John in mind!

CALAMITY IN THE KELP: RECENT DISRUPTION OF DYNAMICS AMONG SEASTARS, URCHINS, ABALONE, AND KELP ALONG THE SOUTHERN OREGON COAST
Rumrill, S.S.*

Oregon Department of Fish and Wildlife

As a preeminent kelp forest ecologist and renowned echinodermologist, the late John Pearse was intrigued, perplexed, and troubled by recent disruption of marine ecosystem dynamics along the southern Oregon coast. Over the past several years, Oregon experienced an unusual series of events
that cascaded throughout the rocky subtidal habitats to contribute to a *calamity in the kelp community*. Like other areas along the west coast, a record-breaking marine heatwave occurred in Oregon’s nearshore waters beginning in 2013-2015. Changes in nearshore ocean conditions contributed to a suite of impacts to rocky shore communities, including mass mortality of seastars, unusual variability in the spatial extent of bull kelp beds, dramatic increases in the abundance of purple sea urchins, and declines in the density of red abalone. Considered together, these ecological changes to rocky reef habitats and communities are unprecedented in recorded history for the southern Oregon coast. As one of John’s graduate students in the early 1980’s, I benefitted substantially from his encyclopedic knowledge, consummate expertise, and infectious curiosity. I will forever appreciate John’s guidance and mentorship, always delivered with his characteristic chuckle and wink of an eye. *Thank you, my friend* is far too modest to express the depth of my appreciation. I can only hope that the legacy of John’s wisdom, keen insights, and acumen may have the lasting impact needed to address the challenges posed by the kelp forest calamity that threatens the west coast today.

**LONG-TERM MONITORING, AND THE LEGACY OF A NATURALIST** *(YOUTUBE)*

Miner, C.M.∗; Bell, C.; Gaddam, R.

*UC Santa Cruz*

John Pearse’s career began at a time when many believed the ocean was vast enough, and resilient enough, to handle anything humans threw at it. However, views were rapidly shifting, and regulations were being adopted to protect both the environment and people. When John was hired in 1971 at the new UC Santa Cruz campus, the city was dumping sewage directly into the intertidal at Soquel Point. With his colleague William Doyle, John initiated a sampling effort in 1973 to document the abundance and diversity of species present there and at a control site to capture changes that might occur when the discharge was terminated in 1976. John had the vision to plan these annual sampling events to coincide with the end of his intertidal biology class, when a new group of enthusiastic students, freshly trained in species identification, would be available to help. This strategic and frugal approach grew into one of the longest, continuous monitoring efforts on the Pacific Coast—now nearly 50 years old! The core ideas of this effort—designing protocols that are sustainable and robust, valuing taxonomy and natural history, and incorporating frugality to maintain longevity—have been adopted by the Multi-Agency Rocky Intertidal Network (MARINe). In fact, John personally trained and inspired many of the researchers involved with this coast-wide, long-term monitoring program. Today, our shorelines face many threats less obvious than a sewage outfall, but the core monitoring principles embraced by John are still essential to understanding how anthropogenic forces alter natural communities.

**NON-NATIVE SPECIES COLONIZATION OF HIGHLY DIVERSE, WAVE SWEPT OUTER COAST HABITATS IN CENTRAL CALIFORNIA** *(YOUTUBE)*

Zabin, C.J.1∗; Marraffini, M. 1; Lonhart, S.I. 2; McCann, L. 1; Ceballos, L. 3; King, C. 2; Watanabe, J. 4; Pearse, J.S. 5; Ruiz, G.M. 1

1- Smithsonian Environmental Research Center 2- Monterey Bay National Marine Sanctuary, NOAA 3- California State Lands Commission 4- Hopkins Marine Station, Stanford University 5- Joseph M. Long Marine Laboratory, University of California, Santa Cruz

More non-native species (NNS) are reported from harbors, estuaries and protected embayments than from wave-exposed, open-coast habitats. In California, hundreds of NNS have become established in international ports, and dozens are known from smaller estuaries. In contrast, only 22 NNS are reported from the state’s 1350 km of open coast. As a result, the perception that open-
coast habitats are not vulnerable to invasions has persisted. Management and monitoring focuses on ports and estuaries; the last major monitoring effort on the open coast occurred in 2004. Much of the species-rich Central California coast is now part of a network of marine protected areas (MPAs). We surveyed 12 wave-swept rocky intertidal and eight subtidal sites (from 37°53′40N 122°42′30W to 36°31′16N 121°56′22W) for NNS. At least one NNS was detected at half of the sites surveyed, but most were not widespread or abundant. One exception, a bryozoan in the Watersipora spp. complex, known primarily from ports and estuaries, was found at multiple sites, and was abundant at some. Another non-native, the alga Caulacanthus ustulatus, was abundant at a single site. MPAs were just as likely as sites outside of MPAs to have NNS. For subtidal sites, proximity to a harbor was correlated with the abundance of non-natives. Our findings suggest that our study area is still relatively uninvaded, but the success of Watersipora within some of these highly diverse rocky shore sites underscores the potential vulnerability of high-value open-coast systems to invasions.

Ocean sentinels: repeat studies for tracking environmental change (YOUTUBE)
Micheli, F. 1*; Carlton, J. 2; Pearse, J. 3; Selgrath, J. 4; Elahi, R. 4; Watanabe, J. 4; Mach, M. 4; McDevitt-Irwin, J. 4; Pearse, V. 4; Burnett, N. 4; Baxter, C. 4

1- Hopkins Marine Station and Stanford Center for Ocean Solutions, Stanford University 2- Maritime Studies Program, Williams College 3- Department of Ecology and Evolutionary Biology, University of California, Santa Cruz 4- Hopkins Marine Station, Stanford University

With growing pressure on ecosystems, it is critical to track ecological change, but initiating and maintaining long-term ecological monitoring is challenging. An additional source of insight on long-term ecological change is repetition of comprehensive studies conducted at a particular site over time spans of decades to centuries. Here, we report the results of longitudinal re-sampling of a study initiated 88 years ago at Stanford University’s Hopkins Marine Station, Pacific Grove, California, USA. We highlight its broader implications for reconsideration of marine field stations as long-term ocean sentinels. Importantly, we honor John Pearse as an extraordinarily effective and passionate connector, catalyst and supporter of broad collaboration and involvement for studying and protecting our marine ecosystems.

LiMPETS WITH JOHN PEARSE (YOUTUBE)
Murray, D.A.*

Antioch University

I will discuss the creation of the LiMPETS monitoring program, the vision of Dr. John Pearse. Many early mornings, methods discussions and adjustments, sheets of wet paper, headlamps, donuts and hip waders later, LiMPETS is still thriving today. LiMPETS (Long-term Monitoring Program and Experiential Training for Students) is a citizen science program for students, educators and volunteer groups. Citizen scientists monitor the coastal ecosystems of California’s national marine sanctuaries, increasing awareness and stewardship of these important areas. The statewide program connects over 6,000 citizens annually to the ocean, involves them directly in a hands-on scientific endeavor and increases their knowledge of the marine environment. This is an educational program and a data collection endeavor, John’s mission was to archive and share his data collected over many years in the intertidal zone so that generations to come could continue monitoring the intertidal and experiencing the mystery and joy of the tide pools in perpetuity. LiMPETS participation is creating a new generation of informed and engaged ocean stewards and is one of John’s legacies that will continue preserving the intertidal.
OUR PROJECT IN HAWAI’I’S INTERTIDAL (OPIHI): LONG-TERM MONITORING INSPIRED BY LIMPETS (YOUTUBE)
Philippoff, J.K. 1*; Rocha De Sonza, M. 1; La Valle, F. F. 2; Schaefer, J. 3; Faucci, A. 4; Nichols, P. 1

1- University of Hawaii at Manoa 2- Scripps Institution of Oceanography 3- University of California Davis 4- Leeward Community College

Our Project In Hawai’i’s Intertidal (OPIHI) is a citizen science program that engages teachers and students in surveying intertidal sites in their communities. The program was modeled after LiMPETS (Long-term Monitoring Program and Experiential Training for Students), a program the late Dr. John Pearse worked with for many years. The name OPIHI comes from the culturally important ‘opihim’ that lives in Hawai’i’s intertidal. OPIHI aims to enhance participants’ scientific literacy skills, increase stewardship of local coastal communities, and enhance connections to place by engaging novices in authentic research experiences.

Just as in California, Hawai’i’s intertidal is important to monitor as its ecological position makes it vulnerable to threats such as land-use changes, species invasions, and climate change. However, the intertidal zone of Hawai’i is difficult to study as seasonal wave activity, a limited low tide window, and modest tidal range mean the ecosystem is often underwater or inaccessible. The difficulty in studying this ecosystem makes it ideal for citizen science research.

Since 2016, we have worked with 82 teachers and ~4200 students in grades 5-12 to take 152 field trips to 46 rocky intertidal sites statewide. In this presentation, we will share how we are introducing teachers and students to the intertidal, using it as a model ecosystem in which to study ecological change, publishing our findings, and channeling John Pearse in passing on our passion for this environment.

HUMAN ASSISTED DISPERAL: DIOPATRA DISTRIBUTION, DISPERsal, RELIC POPULATIONS, GENETICS (YOUTUBE)
Woodin, S.A. 1*; Galaska, M.P. 2; Wethey, D.S. 1; Arias, A. 3; Dubois, S.F. 4; Halanych, K.M. 5

1- Department of Biological Sciences, University of South Carolina, Columbia, South Carolina 29208, USA 2- Joint Institute for the Study of the Atmosphere and Ocean, University of Washington and NOAA Pacific Marine Environmental Lab, Seattle, Washington 98115, USA 3- Departamento de Biología de Organismos y Sistemas (Zoología), Universidad de Oviedo, Oviedo 33071, Spain 4- IFREMER - Centre Bretagne - DYNÉCO LEBCO, F-29280 Plouzané, France 5- Department of Biological Sciences, Auburn University, Auburn, Alabama 36849, USA

Habitat exploration often reveals that distributions of species thought to be continuous are disjunct. Disjunct populations raise the fundamental question of whether the distributional extremes represent historical biogeographic processes or new introductions. The ecosystem engineer Diopatra biscayensis on the Atlantic coast of Europe is a poster child for such questions. The geographic distribution of the species is restricted to the Atlantic coasts of Spain and France, with continuous populations in the Bay of Biscay from the central north coast of Spain to southern Brittany in France and then more than 400 coastal kilometers away, disjunct populations along the English Channel. Given its short-distance dispersal and lack of a historical refuge in the English Channel, the disjunct source is likely the exchange of aquaculture materials between mussel seed collection sites with large Diopatra populations in the Bay of Biscay and aquaculture sites in the Bay of Mont-Saint-Michel. We found juvenile Diopatra on aquaculture boxes and live oyster and mussel shells.
To explore further origins of populations we used genetic analysis of population samples across the biogeographic range using a RAD-tag based SNP approach to recover fine scale population structure. Consistent with human-assisted exchange, the disjunct Bay of Mont-Saint-Michel locality is a subset of the diversity found in the Bay of Biscay. These genomic findings support the hypothesis that *D. biscayensis* phylgeographic connectivity is the result of introductions, likely through shellfish aquaculture.

**DEMERIAL LARVAE IN THE DEEP OCEAN: JOHN MAY HAVE BEEN RIGHT.**

Young, Craig M. 1*; Plowman, Caitlin Q. 1; Burgess, Amy 1; Maslakova, Svetlana 1; Eggleston, Dave 2; Ruoying He 2; Arellano, Shawn 3

1- University of Oregon (OIMB) 2- North Carolina State University 3- Western Washington University

In 1969, John Pearse proposed demersal development for a common Antarctic asteroid. Because this conclusion was based entirely on *in vitro* observations of behavior, it was questioned; indeed, Sid Bosch later collected larvae from the plankton. There still remain few examples of demersal development, though many have speculated that it could be important in some environments, including the deep sea. Here we report two lines of evidence suggesting that demersal development occurs in the bathyal chemosynthetic mussel *Bathymodiolus childressi*. First, larval traps on the sea floor collect larvae of all sizes, not just competent pre-metamorphic individuals. Second, oxygen-18 signatures of larval and juveniles shells from the same individuals indicate that most larvae develop at the same cold temperature as the juveniles. We propose a bet-hedging strategy in which many larvae drift demersally, while a few individuals swim to shallow water for long-distance dispersal. On the basis of existing evidence, a similar strategy cannot be discounted for *Odontaster validus*.

**Larvae depend on cues from surface bacteria to settle and metamorphosis: is it symbiosis?**

(YOUTUBE)

Hadfield, M. G.; Freckelton, M. L.; Nedved, B. T.

*Kewalo Marine Laboratory, University of Hawaii at Manoa*

More than 70% of the earth’s surface is covered by saltwater, yet we know less about the establishment and maintenance of communities of animals on the benthos than we do about a forest. Abundant evidence supports the hypothesis that responses to habitat-specific microbes cue larvae of most benthic invertebrates to settle in sites appropriate for their feeding, growth, maturation and reproduction. We present experimental data that demonstrate the dependence of larvae of a serpulid polychaete, some sponges and a coral on cues from single bacterial species resident in surface biofilms from an estuary and a coral reef to settle onto the benthos. Literature on animal-microbe symbiosis includes increasing evidence for aspects of development to be dependent on products supplied by specific internal bacteria. We suggest that the prior evolutionary step in establishing such symbioses is larval dependence on cues from specific environmental microbes to stimulate successful settlement and metamorphosis.

**SEX IN THE SUPRALITTORAL: DRAMATIC SEX DIFFERENCES IN THE SPLASHPOOL COPEPOD TIGRIOPUS CALIFORNICUS**

Edmands, S*

*University of Southern California*

The copepod *Tigriopus californicus* provides a model for understanding sex-specific tradeoffs between stress tolerance and lifespan. As inhabitants of the extreme environment of supralittoral splashpools, both sexes are extremely tolerant of extrinsic stress. Females, however, have greater
tolerance, withstanding higher temperatures, both higher and lower salinities, and higher pollution levels. Females also show a milder transcriptomic response to extrinsic stress. While high stress tolerance is often associated with longer life, female lifespan is equivalent or shorter than male lifespan. These sex differences may be partially explained by dramatic differences in mitochondrial function, with females investing in mitochondrial maintenance, while males invest in mitochondrial respiration and accumulate greater DNA damage. Sexual dimorphism in factors such as stress tolerance and lifespan can be expected to result in altered adult sex ratios as environmental conditions change.

NEON SEA ANEMONES: A FLUORESCENT PROTEIN OPERATES AS AN ANTIOXIDANT IN ANTHOPLEURA SP. (YOUTUBE)
Clarke, D.N.1; Rose, N.H. 2; De Meulenaere, E. 3; Rosental, B. 4; Pearse, J.S. 5; Pearse, V.B. 6; Deheyn, D.D. 3

1- Hopkins Marine Station, Stanford University. Present address: Massachusetts Institute of Technology 2- Hopkins Marine Station, Stanford University. Present address: Princeton University 3- Scripps Institution of Oceanography 4- Hopkins Marine Station, Stanford University. Present address: Ben Gurion University 5- Long Marine Lab, University of California, Santa Cruz 6- Institute of Marine Sciences, University of California, Santa Cruz

A true ‘tidepooling with John’ story, this project began in the intertidal when John Pearse introduced us to the rare and striking ‘neon’ green color morph of the Sunburst Anemone, Anthopleura sola. To determine the cause of the coloration, we isolated the pigment associated with the ‘neon’ morph and discovered that A. sola produces a GFP-family fluorescent protein in the green-yellow spectrum (530nm emission), which we call ‘Anthopleura YFP’. We determined that the ‘neon’ morph is the result of a single amino acid mutation in the YFP gene that makes it a physically brighter fluorescent protein. The YFP is also more than twice as abundant in ‘neon’ individuals than in the common ‘dull’ morph due to the higher expression level of the ‘neon’ allele. We hypothesize that the ‘neon’ allele may be deleterious or under balancing selection, because ‘neon’ individuals occur at low frequency (~1%), are heterozygous for the ‘neon’ variant, and have lower levels of chlorophyll in their algal endosymbionts. Through comparison to two other sympatric Anthopleura species, A. elegantissima and A. xanthogrammica, we demonstrate that the presence of the YFP is a common trait to this species complex, and that it may have an ancestral function as an antioxidant to buffer against oxidative stress. These results provide the first biochemical evidence suggesting that GFP-family proteins may function as antioxidants in vivo.

A legend to get a star on the Naturalist’s Walk of Fame (YOUTUBE)
Eernisse, D.J.1; Strathmann, M.F. 2

1- Cal State Fullerton 2- Friday Harbor Labs, Univ. of Washington

As part of our ongoing systematic revision of the West Coast members of the exceedingly complex yet fascinating genus of seastars, Henricia Gray, 1840, we decided to honor the late Professor John Pearse, well known for his studies on the reproduction, ecology, and natural history of worldwide echinoderms. By our tally, over half (74) of his 130 publications (and over 4,000 of his 5,407 total reported citations) were on echinoderms, and nearly half again of those publications featured asteroids. (Dr. Pearse studied sea urchins even more.) We have been able to sort out a complex of multiple mostly bright orange seastar species that have long been mistaken for a single species, Henricia leviuiscula (Stimpson, 1857), using a combination of spine-tip morphology, color in life, and mitochondrial DNA sequence distinctions. One of these is quite common in the area of the San Juan Islands where we first started our study, but whose range extends at least from Alaska to Oregon. It
can fortunately be recognized while alive by its characteristic aboral/oral coloration pattern. In a manuscript forthcoming, we have named this new species after John Pearse, and suggest that because it is common and easily recognized, it would be an appropriate target for further study. Any research that helped us better understand these seastars would have delighted John Pearse.

Session 29: Special Session: Conducting Field Research in the Time of Covid/Socioecological perspective on kelp forest recovery
* indicates presenting author, † indicates eligibility for Best Student Paper Award

LIVING ROOM REefs & COUNTERtop CORALS: OPEN ACCESS OCEANS THROUGH 3D MODELS AND AUGMENTED REALITY (YOUTUBE)
de Jong, C.X.*; Woolsey, E.S.

The Hydrous

Less than 2% of the Smithsonian Institution’s collections of more than 155 million artifacts and specimens are on physical display at any one time. Coral Collections – a partnership between the Smithsonian Institution and The Hydrous – offers unique access to coral reef specimens housed by the National Museum of Natural History in Washington, D.C. The collection features 100 three-dimensional (3D) scans of marine specimens, curated through an interactive, educational, and open access virtual platform. This project aims to support “discovery through digitization,” showcasing specimens which otherwise would not be available to the general public. Efforts by technologists at the Smithsonian Digitization Program Office’s (DPO) 3D Program primarily leveraged turntable photogrammetry, where an array of cameras capture photographs at multiple angles around the specimens. Technicians then stitched together the images with specialized software, resulting in high-resolution, 3D digital models. Models are free to download and 3D printable, suitable for use by researchers, educators, and artists. The augmented reality (AR) feature in Google Model Viewer allows for users to superimpose models onto real-world environments. The unique opportunity to bring specimens to the comfort of one’s own space demonstrates the versatile nature of integrating emerging technologies into the traditional scope of artifact display and interaction. This project also emphasizes the importance of artifact preservation, data integrity, and research accessibility through digital means.

HOW TO HOMEBREW A MARINE LAB DURING A LOCKDOWN (YOUTUBE)
Long, J.D.1*; DeSantiago, R. 1; White, W. 1; Hyde, J.R. 2

1- SDSU 2- NOAA

My research group started an 8-week experiment at our marine lab on 3/6/2020. Two weeks later, San Diego closed its beaches and banned non-essential travel. Despite what my mom would have you believe; marine biologists are not typically considered “essential employees”. Also, finding basic supplies during the early days of this pandemic was impossible (knows anyone who tried to buy t.p. in March or flour in April). Because I was determined to complete our study, I persuaded SDSU to label me essential, convinced lifeguards and cops to let me collect organisms, and Macgyvered a marine lab in my garage with duct tape, cinder blocks, and baking soda. This is a story about creative solutions to the study of abalone declines, invasive seaweeds, and sustainable aquaculture.

FIELD RESEARCH IN SEAGRASS ECOLOGY WITH UNDERGRADUATE RESEARCHERS DURING THE COVID-19 PANDEMIC (YOUTUBE)
Roe, J.R.*; Correy, J.T.; Troyan, R.J.; Bittick, S.J.

affiliation not listed
Loyola Marymount University is a private undergraduate serving institution in Los Angeles. The university has been designated the R2 status of "Higher Research Activity" and within the biology department nearly all undergraduate majors participate in research with a faculty member. For several labs focused on ecology and conservation, this includes opportunities to be involved in both lab and field work. Students depend on these experiences to complete senior capstone research projects and to gain experience for their future careers. As is the case everywhere, student research was completely halted in March 2020 and remote work became possible over the summer. Field research was possible for faculty members on their own starting in late June 2020 as local COVID-19 restrictions were relaxed. However, faculty members at LMU depend on the participation of undergraduates to successfully complete field and lab work, so field research was kept to a minimum. Recently (September 2020), undergraduate researchers were approved to conduct field work with enhanced safety measures. Undergraduates from the Coastal Ecology and Conservation Lab at LMU are now beginning field work in seagrass habitats to study the ecology of two species in Southern California, Zostera marina and Z. pacifica. This presentation will be a visual documentation of the current field protocols and provide a first-hand look into undergraduate field research in the time of COVID-19.

**STRUCTURE AND RECOVERY OF EXPLOITED KELP ECOSYSTEMS: EXPLORING THE ECOSYSTEM-BASED PRINCIPLES FOR MANAGEMENT AND RESTORATION**

Perez-Matus, Alejandro 1*; Earp, Hannah 2; Moore, Pippa 3

1- Pontificia Universidad Católica de Chile 2- Aberystwyth University, Wales, UK 3- School of Natural and Environmental Sciences, Newcastle University, UK

The ~8,000 km long coastline of Chile and Peru is dominated by rocky reefs that support one of the most diverse, endemic (~40%) and productive marine ecosystems in the world. Both countries are ranked in the world’s top-ten for fisheries yield with landings valued at ~US$4 billion year-1 and prior to 2002 the kelp fishery was mainly sustained by taking advantage of natural kelp mortality through collection of beach cast material. Since then, harvesting has intensified. In the intertidal, sustainable management solutions have been proposed, mostly through scattered harvesting that allows the persistence of kelp forest’s structure and its associated diversity, as well as kelp’s demographic stability. However, enforcement for such harvesting practice is almost inexistent and clearances are often observed resulted in local deforestation and habitat fragmentation in subtidal environments. Here, we show multiples lines of evidence about the effects of harvesting that compromise the stability of kelp ecosystem and community-wide impacts of kelp harvesting at multiple spatial scales. We explore different management strategies that include restocking of heavily fished areas. For the latter we present results of a quantitative review and meta-analysis of kelp restoration literature in order to; (1) identify trends in kelp restoration success, and (2) to quantify the impact of kelp restoration on kelp abundance and processes. We discuss the results in the context of challenges facing kelp harvesting, restoration research and by doing so, we hope to inform and inspire future kelp resea

**INDIGENOUS KNOWLEDGE OF KEY ECOCLOGICAL PROCESSES CONFERS RESILIENCE TO A SMALL-SCALE KELP FISHERY**

† Kobluk, H.K.1; Gladstone, K. 2; Reid, M. 3; Brown, K. 3; Krumhansl, K. 4; Salomon, A.K. 1

1- Simon Fraser University 2- affiliation not listed 3- Heiltsuk Integrated Resource Management Department 4- Fisheries and Oceans Canada

Kelp forests and humans have been connected for millennia. Now, in the Anthropocene, these dynamic coupled social-ecological systems are faced with quickly shifting conditions, such as novel
climates and new markets. For coastal Indigenous communities, who have enacted customary management of kelp for generations, there is a need to determine how contemporary management can meet concurrent goals of ecological and cultural conservation, and economic opportunity. In collaboration with the Heiltsuk First Nation on the Pacific coast of Canada, we conducted a harvest experiment and interviews with Indigenous knowledge holders to measure the resilience of the feather boa kelp (*Egregia menziesii*) to traditional harvest and determine the environmental drivers of recovery. We found no effect of harvest, and that harvest levels mimicked natural loss. Moreover, Indigenous knowledge of ecological variables driving kelp recovery mirrored our empirical ecological evidence. *Egregia* recovery was driven by individual size and site-specific seawater temperature and wave exposure. Current harvest and stewardship practices allow for *Egregia* recovery and sustained use, but given commercial pressure, continued subsistence use and warming oceans, future management will need to take social-ecological dynamics, cold water refuges and customary law into account. Social-ecological framing, and the consilience of Indigenous knowledge and western science, can bring new insights for sustaining human-kelp forest systems amongst our changing oceans.

**Intraspecific variation in thermal tolerance, and restoring Australia’s disappearing giant kelp (*Macrocystis pyrifera*) forests** *(YOUTUBE)*

Layton, C.*; Tatsumi, M.; Wright, J.T.; Johnson, C.R.

*Institute for Marine and Antarctic Studies, University of Tasmania, Australia*

Kelp forests are the foundation of the Great Southern Reef, Australia’s continent-wide temperate reef system that supports high levels of biodiversity, endemism, and economic value. Unfortunately, in Australia and elsewhere, kelp forests are declining due to climate change, overgrazing from herbivores, and coastal development and pollution. Globally, some of the most dramatic declines have occurred in Tasmania, Australia, where 95% of giant kelp (*Macrocystis pyrifera*) surface canopies have disappeared over recent decades. The restoration of these underwater giants is being assessed as one potential tool for kelp forest conservation. We outline the key driver of giant kelp forest loss in Australia – increasing water temperatures and associated reductions in coastal nutrients – and present a novel restoration approach involving the identification, breeding, and outplanting of more thermally-tolerant giant kelp genotypes. This work is the foundation of potential future efforts to maintain and restore kelp forest resilience in an ocean warming hotspot, and addresses critical knowledge-gaps to provide risk-management to restoration in a rapidly changing climate.

**TIME TRAVEL AND TIPPING POINTS: INFORMING SAFE AND JUST OPERATING SPACE FOR CANADA’S PACIFIC KELP FOREST SYSTEMS** *(YOUTUBE)*

Salomon, A.K. 1*; Burt, J.M. 2; Kii’ljuus, B.J.W. 3; McKechnie, I. 4; Slade, E. 5

1- Simon Fraser University 2- Nature United 3- Council for the Haida Nation 4- University of Victoria 5- Parks Canada

At the end of the Pleistocene, following deglaciation, the assembly of nearshore ecosystems and the peopling of North America’s Pacific coast occurred concurrently. It is surprising therefore, that during the Anthropocene, people are often absent from both kelp forest food webs and conversations about their restoration and management. Through a research partnership with 19 First Nations and using a social-ecological lens, we braided multiple sources of evidence to illuminate the changing relationships between people, sea otters, kelp forests and nearshore fisheries through time. Traditional knowledge and archaeological evidence from 3,000 yr-old middens reveal that Indigenous communities maintained access to significantly larger shellfish than
those found at shorelines with high sea otter numbers today, suggesting that sea otters were maintained well below carrying capacity along some shorelines. Social-ecological evidence from coastal communities experiencing sea otter-induced rocky reef tipping points today suggests that coexistence of people and sea otters is enabled by strengthening Indigenous governance authority and establishing adaptive co-management that incorporates Indigenous knowledge and objectives. Broadly, operating within the ecological boundaries of our oceans while ensuring their equitable use requires an understand of the interactions between ecological and social phenomena across scales of space and time.

**Kelp forest ecology facilitated by citizen science in Ireland** (YOUTUBE)
Kathryn M. Schoenrock1; Kenan M. Chan 1; Tony O’Callaghan 2; Rory O’Callaghan 2; Aaron Golden 3; Stacy A. Krueger-Hadfield 4; Anne Marie Power 1

1- Department of Zoology, Ryan Institute, NUI Galway, Galway, Ireland 2- Seasearch Ireland 3- Department of Maths and Statistics, Aras de Brun, NUI Galway, Galway, Ireland 4- Department of Biology, University of Alabama at Birmingham, Birmingham, AL, 35294, USA

Subtidal kelp forests in the north east Atlantic are dominated by the perennial species *Laminaria hyperborea*, which can produce over 11 kg raw biomass m\(^{-2}\) and provides carbon for food webs from the intertidal to the deep sea. This cold-water kelp is an ecosystem engineer that is slowly retreating from its southern distribution limit as the North Atlantic Ocean warms. Over the past four years, extensive surveys, field experiments and collections of both bedrock and kelp tissue from kelp forests located across Ireland’s coastline have been sampled to investigate resilience in this foundation species from an evolutionary and ecological perspective in cooperation with Seasearch Ireland, a citizen science group dedicated to monitoring nearshore habitats in Ireland. We discuss how intensive sampling of this kind is only possible with Seasearch Ireland, and the mutually beneficial relationship that can be sustained through long term citizen science monitoring and targeted scientific projects. Our combined research efforts are the first step toward understanding not only the biodiversity and productivity of Irish kelp forests but the population dynamics of *L. hyperborea* at a genetic level, including those of the microscopic haploid stage which is rarely studied.

**RETURN OF THE KING: WHAT CAN ACOUSTIC TELEMETRY DATA TELL US ABOUT THE RECOVERY OF GIANT SEA BASS (STEROLEPIS GIGAS)?** (YOUTUBE)
Spector, P. 1; Freedman, R. 1; Clevenstine, A 2; Caldow, C. 1; Peavy-Reeves, L. 1

1- NOAA Channel Islands National Marine Sanctuary 2- California Department of Fish and Wildlife

Once abundant on rocky reefs across southern California and Central Baja California, Giant Seabass (*Stereolepis gigas*) populations have been greatly reduced due to fishing pressure and habitat loss. The population has been steadily recovering since being placed under state protection in California in the 1970s but we have limited understanding of their behavior and role in the kelp forest ecosystem. As populations of *S. gigas* begin to recover, modeling their movements is fundamental to understanding their ecology and natural history and for exploring mechanisms affecting individual and population-level processes. This study uses acoustic telemetry to track *S. gigas* at Santa Barbara Island, a remote island in LA County. Evidence suggests that these large, piscivorous fish, aggregate for foraging and reproductive success and our work shows these fish have small home ranges and high site fidelity for specific coastal areas. However, individuals are capable of long distance movements as tagged fish have moved from Catalina to the northern Channel Islands. Identifying aggregation spots and their purpose is critical to further protecting this species as it recovers in the
southern California Bight. Therefore, by understanding their movement ecology and behaviour, marine managers can better protect these sentinels of recovery and change on rocky reefs.

**REIMAGINING THE KELP HIGHWAY: A SOCIO-ECOLOGICAL EXPEDITION TO HIGHLIGHT PUGET SOUND’S MARINE FORESTS** *(YOUTUBE)*

Toft, J.E.;* Peabody, B.; Hayford, H.; Allen, B.; McKenna, G.

*affiliation not listed*

Kelp is an underpinning of the Salish way of life in the Pacific Northwest. For thousands of years, a connected ribbon of kelp forests fringed nearshore waters, supporting people, fish, and marine mammals by providing safe canoe passage, direct and indirect food sources, and refuge and habitat for fish and invertebrates. Aptly called “the kelp highway,” anthropologists have traced a kelp-bound coastal route used by first Americans as they migrated from Asia. While overland routes remained icebound, this ancient coastal migration route delivered a subsistence package of marine foods that enabled travel and supported settlement.

Today, fringing underwater forests are a fraction of their former abundance along the US West Coast. Documented kelp declines can lead to an unraveling of ecological functions, and destabilization of fisheries. To rebuild kelp forests, and catalyze community engagement needed for recovery, we need a clear depiction of historic and current extent and a compelling strategy for engaging partners. To this end, Puget Sound Restoration Fund and partners have joined hands to re-trace and re-imagine the kelp highway.

I will describe our plans to explore the socio-ecological facets of the kelp highway on a 7-day expedition through Puget Sound in 2021. Along the way, we will ground truth current distribution, survey underwater biodiversity, renew cultural connections, and illuminate the importance of kelp forests. As a whole, the activities will generate momentum for implementing actions in the 2020 Puget Sound Kelp Conservation and Recovery Plan.

**LESSONS LEARNED: GIANT KELP FOREST RESTORATION IN ORANGE COUNTY, CA 2002-2012** *(YOUTUBE)*

Caruso, N.L.*

*Get Inspired*

Kelp forests around the world are in decline. The need for Kelp forest restoration is not a new problem nor is it a new science, it began in the 1960’s. The largest kelp restoration effort to date took place from 2002-2012 in the Southern California bight and here we share some of the lessons learned. After 3 decades of kelp forest decline, by 2000 the southern California bight had lost 80% of its giant kelp forests. In 2002, NOAA funded a community-based giant kelp restoration project to be conducted in this region. The funds were awarded to the California Coastkeeper Alliance and included efforts in Santa Barbara, Los Angeles, Orange, and San Diego counties on 320 km of coast. It was a major undertaking, there was one paid biologist in each county and a funded kelp mariculture laboratory located San Pedro. No peer reviewed publications came out of this project but the information is vital to the effective use of restoration funds for future projects such as those in Northern California being used right now. As Dr. Wheeler North shared, "You can't just plant a few kelp plants and walk away". Persistence, adaptation, and the need for "supportive" ocean conditions were the biggest lessons learned.

Session 30: 15 Minute general 3

* indicates presenting author, † indicates eligibility for Best Student Paper Award
LENGTH-FREQUENCY DISTRIBUTIONS AND HABITAT ASSOCIATIONS OF COASTAL CALIFORNIA FISHES ACROSS A LATITUDINAL GRADIENT

Cieri, K.P. 1; Starr, R.M. 1; Gleason, M. 2; Fields, R. 3; Mohay, J. 1; Matthews, K. 1

Deep-water habitats, made up of rocky banks and outcrops, underwater pinnacles, and submarine canyons, represent at least 75% of the area of all marine habitats in California, and yet far less is known about these habitats and their associated fishes than shallower habitats in depths less than 30 meters. These deep, rocky habitats off California host a high diversity of demersal fishes; they are home to over 100 taxa, including over 50 species of Rockfish (Sebastes spp.). Rockfishes in particular have been subject to overfishing due to their long lifespans, slow growth, and late age of maturity, with many stocks only recently declared recovered. We have surveyed these deeper areas in California over several years using two stereo-video lander systems in order to better understand fish species and their habitat associations. Using these data, we are investigating yearly differences in length-frequency distributions and habitat associations of demersal fishes across a latitudinal gradient. This research will improve our understanding of spatial variability in stock characteristics, and ultimately inform future management of these valuable species.

Estimating inter-diary variation in fish densities from video surveys near Monterey, CA

Mohay, J.L. 1; Starr, R. 1; Gleason, M. 2; Cieri, K. 1; Fields, R. 3

Visual surveys are often used to assess habitats, species populations and changes among them over time. A common assumption when conducting visual surveys for population dynamics is that, although there may be seasonal variation, there is little daily variation. This implies that differences observed among survey days are due to spatial, not temporal, variation. In June 2019, in collaboration with the Monterey Bay National Marine Sanctuary, we spent 5 consecutive days surveying Portuguese Ledge, Monterey, CA to assess inter-diary variation of benthic fishes. We used the BOSS video lander, a 9-camera system with fiberoptic tether that enabled viewing and recording of fishes at the surface. We deployed the lander on high-relief habitats selected using multibeam maps and recorded 3-minute videos at 93 sites from June 25-28. We analyzed the video using EventMeasure (SeaGis, Australia) counting each species at a MaxN frame and measuring total lengths. Average densities estimated at Portuguese Ledge were not significantly different among days for any species except Ophiodon elongatus and Sebastes levis. There was a significant difference in average density among days for pooled ground species of interest.

SPATIAL PATTERNS IN JUVENILE FISH ABUNDANCE THROUGHOUT THE CALIFORNIA MPA NETWORK AS REVEALED BY SEABIRD FORAGING RATES

Robinette, D.P.; Nur, N.; Jahncke, J.

Adaptive management of marine protected areas (MPAs) requires an understanding of spatial variability in the rates of juvenile recruitment to recovering populations. We used foraging rates of two coastally breeding, piscivorous seabirds to index juvenile fish recruitment to nearshore habitats at 46 sites throughout California’s MPA network. Each seabird species preys heavily on juvenile size classes of demersal fish species. We used mixed effects negative binomial regression to
develop models relating foraging rates to coastal geography and annual upwelling. The best models for both species included upwelling variability (i.e., persistent versus pulsed upwelling). The effects of upwelling variability differed depending on coastal geography. Foraging rates were highest in the lees of headlands and more stable against upwelling variability. For all other coastal configurations, pulsed upwelling led to higher foraging rates. Pulsed upwelling has been shown to reduce offshore transport of planktonic larvae and increase larval retention to nearshore habitats. Studies have also shown persistent recruitment in the lee of headlands where eddies form and retain larvae. Our results suggest that 1) coastal geography should be considered when establishing realistic expectations for MPA performance and for prioritizing new areas for MPA designation and 2) foraging rates of coastally breeding seabirds can provide a spatially explicit index to assess spatial and temporal trends in juvenile fish recruitment to nearshore habitats, thereby helping guide the adaptive management of MPAs.

REDEFINING RISK IN DATA-POOR FISHERIES (YOUTUBE)
† Grewelle, R.E.*; Mansfield, E.J.; Micheli, F.; De Leo, G.

Hopkins Marine Station, Stanford University

The Productivity Susceptibility Analysis (PSA) is a widely used method to rapidly assess species risk to fishing activities in data-poor fisheries. Adopted as the second step in the Ecological Risk Assessment for the Effects of Fishing and used in data-poor assessment for sustainable fisheries certification programs (e.g. MSC) and recommendation lists (e.g. Seafood Watch), the PSA is semi-quantitative, yet little attention has been given to the theoretical basis of this analysis. Current thresholds designating risk categories divide the PSA plot by equal area, assuming area corresponds to likelihood. We show that plot area does not correspond to likelihood, and existing thresholds need revision due to the non-uniform distribution of vulnerability scores on the PSA plot. The probability of a stock to be classified as medium risk increases with the number of attributes used to characterize productivity and susceptibility. We present a novel and statistically robust method to derive vulnerability, where threshold values between risk categories are adjusted depending upon the number of attributes used in the assessment. This framework accounts for common variations in the method, including logarithmic scaling of axes, weighting of attributes, and scoring procedures. Simulated results across a range of conditions as well as comparative evaluation of 166 species in the 2008 NOAA report show that on average one-third of species may be re-categorized with the new PSA approach. The existing PSA approach underestimates risk by up to 35% when compared with the new method.

CHANGES IN FISH COMMUNITIES IN DEEP ROCKY PORTIONS OF CALIFORNIA MPAS (YOUTUBE)
Ziegler, S. L.¹; Caselle, J.E. ²; Kahn, A.S. ¹; Lauermann, A. ³; Lindholm, J. ⁴; Tissot, B.N. ⁵; Bretz, C. ⁴; Cieri, K. ¹; Mohay, J. ¹; Salinas Ruiz, P. ⁴; Starr, R.M. ¹

1- Moss Landing Marine Labs 2- UC Santa Barbara 3- Marine Applied Research and Exploration (MARE) 4- CSU Monterey Bay 5- Humboldt State University

Deepwater habitats (~50-300m) represent at least 75% of the area of all marine habitats along the coast of California and range from relatively low-relief sandy habitats to high-relief rocky reefs. All demersal fishes that were designated as overfished in California in the early 2000s utilize these deepwater habitats for a portion of their life cycle. To mitigate the effects of environmental and human-induced stressors, marine protected areas (MPAs) have been employed across the globe to protect coastal habitats, and enhance overall biodiversity and fisheries production. Due to the global variation in MPA areas and protection levels, however, the outcomes of MPAs are highly context-dependent, and vary across both space and time. Between 2007 and 2012, California
established a network of MPAs to preserve and protect the abundance, integrity, and diversity of marine life, habitats, and ecosystems. To assess how deepwater fish communities in California responded to MPA formation across a wide latitudinal gradient, we compiled and evaluated over 25 years of data from multiple video tools: a piloted submersible, remotely operated vehicles, a rotating lander, and a stereo-video lander, the Benthic Observation Survey System. We used these data to determine how the biomass of deepwater fishes has changed through time inside and outside of MPAs. Evaluating the relative success of MPAs is complex as these ecosystems are dynamic and individual species and communities react differently to protection across regions and with varying environmental conditions.

USING UNMANNED AERIAL VEHICLES (UAVs) TO ESTIMATE DENSITY OF TWO THREATENED SPECIES IN THE PINACATE BIOSPHERE RESERVE (YOUTUBE)
† Barkai, L.B.1; Talley, D 2

1- University of San Diego 2- Department of Environmental and Ocean Sciences, University of San Diego

There are around 1400 species of cacti worldwide, and nearly half of them - 669 species - are found in Mexico, with 518 being endemic. This project focused on the change in cactus populations in the Mexican Sonora Desert from 2006 to 2019. We estimated the density of two threatened cacti species: the saguaro cactus (Carnegiea gigantea) and the teddy bear cholla (Cylindropuntia bigelovii) in the Pinacate Biosphere Reserve. Cacti were censused by analyzing photo images from an Unmanned Aerial Vehicle ("drone"). Some historical census data for the cholla were available for the years 2004, 2014, and 2018 from a small (~1000m^2) study site nearby called Cactus Junction. I collected new data from a much larger (~100k m^2) nearby site. For this site, we compared data from UAV images to the population abundance that was recorded from on-the-ground surveys in our study site in 2006. In conclusion, the two cacti experience population declines (Cylindropuntia bigelovii by 37% and C. gigantea by 61%) from 2006 to 2019 and Cylindropuntia bigelovii decline was higher in Cactus Junction with 77% between 2004 – 2018.

EXPERIMENTAL WARMING ENHANCES EFFECTS OF EELGRASS GENETIC DIVERSITY VIA TEMPERATURE-INDUCED NICHE DIFFERENTIATION (YOUTUBE)
DuBois, Katherine*; Williams, Susan.L; Stachowicz, John.J

UC Davis

Genetic diversity within coastal foundation species can enhance species and ecosystem resilience to ocean warming and marine heatwaves. However, the effects of diversity on ecosystem function are often context dependent and mechanisms underpinning such contingency remain poorly understood. To test the relationship between genetic diversity and resilience to warming in a coastal foundation species we planted eelgrass (Zostera marina) pots at two levels of genotypic richness (1 genotype monocultures or 4 genotype mixtures) and exposed these pots to warming events of different frequencies (sustained or alternating) in mesocosms for four months (mid-summer to late fall). Our results revealed that in monocultures warming reduced pot biomass by 15.8% but warming led to overyielding in mixtures by 33.3%. In contrast, mixture biomass at control temperatures underyielded by 13.2%. Overyielding of mixtures during sustained warming was driven by positive complementarity, which appears to be the result of warming-induced shifts in the relative performance of genotypes over time. We propose that high temperature stress created a tradeoff such that some genotypes experienced greater photoinhibition during mid-summer while other genotypes were light limited during the late fall. Thus, seasonal differences in temperature and light conditions in the warming treatment generated asynchrony in genotype peak
performance, freed genotypes from competitive interactions, and allowed overyielding via complementarity to occur.

Session 31: 15 Minute general 4
* indicates presenting author, † indicates eligibility for Best Student Paper Award

EFFECTS OF PREDATORS ON INVERTEBRATE COMMUNITIES ACROSS AN ESTUARINE GRADIENT (YOUTUBE)
† Rubinoff, B.G.; Grosholz, E.D.

UC Davis, Bodega Marine Lab

Estuaries often represent steep stress gradients for organisms, with abiotic stress due to temperature and salinity typically increasing with distance into estuary. Sessile filter feeding invertebrates are abundant in estuaries and harbors, and much of the research on these species has occurred at docks and marinas. While commonly associated with artificial structures, sessile invertebrates often spread to surrounding natural habitats distributed along estuarine gradients. Predation has been shown to significantly influence sessile invertebrate community composition; however, these effects are unknown across a range of conditions. This study examined how effects of predation on sessile invertebrate community composition vary across the estuarine gradient of Tomales Bay, CA. We found that community composition differed across sites, and predation had a significant effect on community composition when averaged across all sites. However, the effect of predation changed across sites, with mid-bay sites experiencing the greatest effects of predators. This was likely due to patterns in functional group abundance, as certain functional groups were more susceptible to predation than others. Overall, predation didn't follow the predictions of the environmental stress hypothesis, but rather followed the distribution of particular functional groups, which could be mediated by environmental stress gradients. Many sessile invertebrate species are invasive, so it is crucial to understand the relative importance of factors influencing their distribution in order to better manage them.

UNDERSTANDING ROLE OF SEAWATER NITRATE ESSENTIAL FOR SUCCESSFUL BULL KELP RESTORATION (YOUTUBE)
Tom W. Bell1; Sara L. Hamilton 2; Katherine C. Cavanaugh 3; Meredith McPherson 4; Max C. N. Castorani 5; Kyle C. Cavanaugh 3; Jennifer E. Caselle 1

1- UC Santa Barbara 2- Oregon State University 3- UC Los Angeles 4- UC Santa Cruz 5- University of Virginia

Bull kelp forests in northern California experienced dramatic declines in recent years due to a ‘perfect storm’ of high ocean temperatures, a boom of herbivorous sea urchins, and the mass mortality of an important sea urchin predator. Kelp forests are dynamic systems that respond rapidly to fluctuating environmental drivers, such as nutrients from coastal upwelling. Remotely sensed timeseries of kelp canopy dynamics have shed light on the relationships between these drivers and kelp dynamics over multidecadal scales. Recently, we developed a remotely sensed time series of bull kelp canopy dynamics for the northern California and Oregon coasts, and unlike northern California, bull kelp forests in Oregon have not experienced dramatic declines in canopy area. Mean annual nitrate concentrations followed similar patterns in both regions, but never fell below 10 μmol L⁻¹ along the Oregon coast. In northern California, a non-linear relationship between maximum annual canopy area and mean annual nitrate concentration exists with a potential growth threshold between 9 and 10 μmol L⁻¹. The decline in bull kelp canopy area below 9 μmol L⁻¹ implies that nutrient limitation may be an important driver of interannual bull kelp dynamics.
Importantly, these fluctuations in seawater nitrate are linked to low frequency marine climate oscillations resulting in distinct nutrient regimes. Restoration is unlikely to be successful if it is performed during periods when physical conditions are not amenable to kelp growth and knowledge of these patterns can also direct restoration strategy.

A COMPREHENSIVE FRAMEWORK FOR UNDERSTANDING CLIMATE CHANGE IMPACTS ON FISHERIES SYSTEMS (YOUTUBE)
† Stoltz, A.D. 1*; Beulke, A.K. 1; Dudley, P.N. 2; Morales, M.M. 1; Nelson, P.A. 1; Pomeroy, C. 1; Rogers, T.L. 2; Sheridan, C.J. 1; Carr, M.H. 1

1- University of California, Santa Cruz 2- NOAA

It is crucial to understand and anticipate the effects of climate change on fisheries and the social-ecological systems of which they are part. With fisheries management increasingly striving to consider interactions and feedbacks among people, targeted fish stocks, and the broader ecological and human communities, fisheries managers need tools that can assess these complex systems. We developed a framework for mapping the potential effects of climate change-induced trends or events on fisheries systems. This framework is a systematic method of accounting for indirect effects, feedbacks, links between subsystems, and multiple climate change-induced stressors. We have demonstrated this framework’s utility on both retrospective and prospective cases. Our framework is unique in the field of Climate Vulnerability Assessment frameworks and applications and is designed to fully consider all significant aspects of both the Ecological and Human Communities. This extent and breadth of consideration makes this framework a systematic method for examining and assessing potential impacts to a fishery system.

COMBINING LABORATORY AND FIELD DATA TO UNDERSTAND TRANSCRIPTOMIC RESPONSES TO LOW-TIDE THERMAL STRESS IN MUSSELS
Connor, K 1*; Gracey, A 2; Chaney, M 2; Boomhower, J 3; Tyburczy, W 4; Somero, G 5

1- UC Irvine 2- USC 3- UCSD 4- NOAA 5- Stanford

Facultative anaerobes evolved in fluctuating environments and possess physiological traits that allow them to effectively cope with periods of hypoxia. The mussel *Mytilus californianus* is a facultative anaerobe that undergoes anaerobic metabolism during low-tide aerial exposure and aerobic metabolism during periods of submergence. In 2008 our laboratory published a study that observed transcriptome patterns in *M. californianus* within a high-shore population over a series of tidal cycles that spanned three warm days in Monterey Bay, CA. Oscillatory patterns were the dominant gene expression signatures observed however, a fine-tuned interpretation of the environmental-gene expression interactions was not fully resolved. Subsequently, we examined the transcriptome of *M. californianus* over a two-day simulated high-shore environment in the lab. The reduced environmental variability in a controlled setting allowed for a high-resolution temporal examination of the transcriptomic response. The results revealed an occurrence of two major gene-expression patterns (daytime-stress and nighttime-recovery). Recently, we tracked the differentially expressed genes observed in laboratory acclimated mussels within the Monterey field data. Remarkably, there was a strong similarity of gene expression patterns between mussels subjected to laboratory and field conditions. This analysis broadens our understanding of the physiological-ecology of *M. californianus* and the biology of facultative anaerobes in general.

INFLUENCE OF GLACIAL MELT ON ESTUARINE INTERTIDAL COMMUNITY STRUCTURE AND THEIR ENVIRONMENTAL DRIVERS (YOUTUBE)
† McCabe, M.K.*; Konar, B.H.
High-latitude coastal environments, such as those found in the Gulf of Alaska, are experiencing dramatic changes due to climate warming. Glacier discharge rates have doubled in the past decade and have modulated downstream environmental conditions in coastal watersheds. These fast changing environments are predicted to influence the structure of local marine communities. Here we examine intertidal community structure, focusing on key ecological groups and their environmental drivers at nine watersheds in two regions, which are separated by approximately 1000 km. Each region has watersheds that span a gradient of 0-60% glacial coverage. Intertidal quadrat surveys and biomass collections, along with environmental monitoring of salinity, temperature, dissolved oxygen, discharge, turbidity, and nutrient loading were completed from April – September 2019 in each watershed. Biological community structure and variance was analyzed in relation to the local environmental spatiotemporal profiles. In general, watersheds with more glacial coverage resulted in higher primary producer percent cover. In contrast, less glacial coverage resulted in fewer filter feeder cover. Specifically, spatial cover of primary producers was negatively correlated with salinity, whereas, barnacle cover was positively correlated. There was a strong positive correlation with turbidity and producer biomass, but a negative relationship between mussel coverage and turbidity. Local circulation and oceanic influences could influence the varying within-ecological group response between regions. Nonetheless, increa

UPWELLING DRIVEN VARIABILITY IN PH, DISSOLVED OXYGEN AND TEMPERATURE DIFFERENTIALLY IMPACT KELP FOREST GRAZERS (YOUTUBE)
† Donham, E.M.*; Kroeker, K.J.

University of California Santa Cruz

Marine organisms are embedded within dynamic oceanographic regimes that play a key role in structuring ecological communities. Yet, few studies have assessed how coupled changes in multiple abiotic factors alter the physiology and ecology of marine invertebrates. Within central California kelp forests, oceanographic conditions are mainly driven by physical processes such as upwelling, resulting in covarying pH, temperature and dissolved oxygen (DO). In isolation, these environmental drivers can alter physiological rates and species interactions and reduce growth and calcification. Here, we utilize a mesocosm system to mimic a gradient in upwelling intensity to simulate natural covariance in pH, temperature and DO experienced within central CA kelp forests. We reared sea urchins, Mesocentrotus franciscanus, and snails, Promartynia pulligo, at six levels of upwelling intensity and measured their metabolic and grazing rates after immediate exposure, 3 days, 1 month, 2 months and 3 months and growth and calcification after 3 months. Results show reduced metabolism, grazing, growth and calcification with increasing upwelling intensity in M. franciscanus. We found a negative effect of increasing upwelling intensity on calcification in P. pulligo after 3 months, but no effect on metabolism, grazing or growth. Responses were consistent across sampling intervals, showing little sign of acclimation over 3 months. Predicted increases in upwelling intensity due to global change could differentially impact kelp forest grazer species with consequences for ecosystem functioning.

DIVERSE SPECIALIST PARASITES IN KELP-FOREST FOOD WEBS DECREASE CONNECTANCE, IN CONTRAST TO OTHER SYSTEMS (YOUTUBE)
Morton, Dana N1*; Lafferty, Kevin 2

1- UC Santa Barbara 2- US Geological Survey
Parasites affect food-web properties simply due to increases in species richness, but parasites also tend to increase food-web complexity as measured by connectance. Parasites also increase maximum food-chain lengths more than expected and can alter degree distribution. However, only a few similar and species-poor food webs include parasites (estuaries, salt marshes, sand flats). We therefore tested whether parasite effects seen in other systems also occurred in a newly constructed kelp-forest food web. We distinguished between the effects of parasitism and concomitant predation (predators eating parasites when they eat infected hosts). We further compared the generality and vulnerability of free-living and parasitic species, as well as the network-level change in these properties when parasites were included. We controlled for network size effects on degree distribution and longest chain by using the niche model as a reference network. Parasites made up a larger proportion of the kelp-forest food web than any other published food web. Consistent with other systems, adding parasites increased longest chain length more than predicted based on network size, but this effect was sensitive to whether concomitant links were included. In contrast to other food webs, connectance decreased and degree distributions changed when parasites were included. This occurred because parasites were relatively more specialized than free-living consumers, and the kelp-forest food web lacked parasite-parasite interactions that were common in other food webs.

Session 32: Special Session: Applied ecology for sustainable aquaculture
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**CLIMATE CHANGE RESILIENCE OF MODEL SPECIES INFORMS SEAWEED AQUACULTURE IN CALIFORNIA**

Kübler, J.E.†; Dudgeon, S.R. ²

*1- CSUN and UCONN 2- CSUN*

The California coastal climate and growing season contrasts with the cold-temperate to Arctic where most of the cultivated seaweed in the US is grown. Climate change is warming coastal waters on average and marine heat waves are increasingly common. Both the average warming trend and episodic marine heat waves co-occur with decreased upwelling, low nutrient events. These events cause diebacks of wild species. Aquaculture can replace wild-harvested seaweeds and expand supplies of California-grown seaweeds, if the species chosen for cultivation are developed with climate-change resilience in mind. Here, we use the model species, *Ulva lactuca* and *Plocamium cartilagineum*, to characterize interactive effects of warming, ocean acidification and nutrient loading climate change resilience in the laboratory. Laboratory studies informed the selection of potentially climate change resilient species for cultivation. We describe our cultivation of golden kombu, *Laminaria farlowii*, a Southern California native species. Using projections of change in upwelling intensity and season in California, we suggest a physiological screening approach to experimentally test for resilience to conditions expected in coastal California by mid-to-late 21st century.

**Herbivorous reef fish microbiome as a tool for digestion of macroalgae**

Augyte, S.*

*affiliation not listed*

ABSTRACT for Western Society of Naturalists

Title: Herbivorous reef fish microbiome as a tool for digestion of macroalgae

Simona Augyte
Sustainable aquaculture is trending in the US with federal opportunities and incentives catalyzing research for off-shore farming. In Hawai‘i, there is interest in culturing herbivorous marine fish, such as Kyphosus vaigiensis (Brassy chub). This family – and other herbivores – offer potential as aquaculture candidates that could thrive on algae-based feeds. Their long gut and digestive tract, makes kyphosids well-suited for the digestion of algal polysaccharides. Furthermore, kyphosids rely on fermentation in their hindgut to utilize algal substrates not taken up directly. Feed trials comparing a diet based on macroalgae and a commercial tilapia one revealed high growth rates on both feeds. Sampling of different sections of the kyphosid gut microbiome are ongoing to determine the microbial community composition and to better understand the processes of degradation of seaweed. Isolation and culturing of selected gut microbes can be tuned for developing an efficient in vitro fermentation-based macroalgae conversion process. The associated metabolic profiling, can then be used for selecting a portfolio of high-value bioproducts from macroalgae to support a sustainable aquaculture.

THE EFFECT OF TWO INVASIVE ALGAE ON RED ABALONE, Haliotis rufescens, GROWTH AND SURVIVAL

† Bauer, J. 1; Emeterio-Cerecero, M. 1; Beas-Luna, R. 1; Lafarga- De la Cruz, F. 2; Montaño-Moctezuma, G. 1; Lorda, J. 1

1- Universidad Autónoma de Baja California 2- Centro de Investigación Científica y de Educación Superior de Ensenada

Non-indigenous species (NIS) represent a major concern to marine conservation. In particular, invasive macroalgae are especially interesting as they may alter ecosystem structure and function. At Todos Santos Bay in Baja California, three introduced brown macroalgae from Asia, Undaria pinnatifida, Sargassum muticum and S. horneri, have become common in the past few years. In the present work, we explored the effect of these abundant invasive algae on the growth and survival of juvenile red abalone fueled by the interest of local fishers and academia to develop abalone conservation aquaculture programs in the region. We first tagged 215 abalone (30 ± 3 mm SL) and fed them with the invasive algae, U. pinnatifida and Sargassum spp., and a control with the native Macrocystis pyrifera. We then measured the growth in shell length, weight, and survival for 90 days. Our results suggest that Juvenile red abalone fed with U. pinnatifida had a total growth (TG) in shell length of 3.8 mm, final weight (FW) 5.7 g, and 98% survivorship. For diet of Sargassum spp., TG was 2.4 mm, FW 4.6 g, and 81% survivorship. For M. pyrifera diet, TG was 3.4 mm, FW 5.6 g, and 95% survivorship. Overall, Sargassum spp. had a negative effect on the abalone growth and survival. It is expected that marine heatwave and other climatic impacts will favor the establishment of invasive species and thus, these results may be relevant to inform local fisheries and management efforts in this area.

AQUACULTURE DESIGN FOR CONSERVATION AND FISHERIES SUSTAINABILITY GOALS

† Couture, J. L.*; Bradley, D.; Halpern, B. S.; Gaines, S. D.

UC Santa Barbara

In order to decrease the U.S. seafood deficit, agencies are looking to marine aquaculture to increase domestic seafood production, in addition to strengthening fisheries management. Healthy ocean ecosystems are important to sustaining these marine seafood industries. The direct impacts of marine farming on local ecosystems is being heavily investigated, but little attention has been given to the indirect impacts of farms on wild populations. Ocean farms are known to attract and aggregate wild species, while at times also limiting access to fishing. We tested how these factors
impact vulnerability or wild species to fishing and the consequences on conservation and fishing outcomes. Like MPAs, the conservation potential of a mariculture farm depends on the systems and species interacting with the farms, as well as the type of farm itself. To better understand the tradeoffs between these parameters, our analysis tests farm design and management for different target species and farm types. This work will inform planning and design of emerging offshore aquaculture in the U.S. that maximizes conservation and fishery sustainability benefits.

**Using seaweed farms to remove excess nutrients from estuarine waterways**

Edwards, M.S. 1*; Bews, E. 1; Booher, L. 2; Polizzi, T. 3; Kim, J-H. 4; Long, C. 1

1- San Diego State University 2- Sunken Seaweed, LLC; San Diego State University 3- Sunken Seaweed, LLC 4- Kunsan National University

Excessive use of fertilizers in urban and agriculture setting results in nitrogen and phosphorus being transported to the ocean, causing health concerns for many bays and estuaries, especially after heavy rain when runoff carries them to the sea. Seaweed farms may prove a promising way to remove excess nutrients but it is unclear how the seaweeds on thee farms will perform when salinities decrease following freshwater input. We studied the feasibility of using *Ulva lactuca* to remove nitrogen and phosphorus from San Diego Bay during periods of reduced salinity. To do this, we grew *U. lactuca* under two salinities and three nutrient concentrations for six weeks. We measured *U. lactuca* growth, photosynthesis, nitrogen and phosphorus uptake, and the resulting tissue carbon, nitrogen and phosphorus contents. Our results show that while *U. lactuca* survived and grew in all salinity and nutrient combinations, its growth, photosynthesis, and tissue nitrogen and phosphorus contents were all affected by differences in salinity and nutrient availability. Specifically, low salinity and low nutrient availability act as limiting factors for these parameters, while high salinity and medium-to-high levels of nutrients generally induced stimulation of these parameters. Our study suggests that although its physiology may suppressed, growing *U. lactuca* on seaweed farms may be a feasible way to clean the water of degradable organic pollutants, especially following rain events that increase nutrient input and lower salinity.

**EELGRASS ECOSYSTEM RESPONSE TO OYSTER AQUACULTURE**

† Lumnis, S.C.1*; Heady, W. N. 2; Klausmeyer, K. R. 2; Fleener, G. 3; Kroeker, K.J. 1

1- UC Santa Cruz 2- The Nature Conservancy 3- Hog Island Oyster Company

Eelgrass plays an important role in estuarine ecosystems, as a habitat-forming species and a nursery for a wide array of fish and invertebrates, and frequently co-occurs with aquaculture activity along the West Coast. It is challenging to monitor eelgrass systems, particularly at a landscape scale, which increases the difficulty of understanding the effects of aquaculture activities on their overall extent and health. In this study, we experimentally tested the impacts of oyster aquaculture on adjacent eelgrass communities and the local environment following a Before-After-Control-Impact (BACI) design in Tomales Bay California. Results from both drone and ground-based surveys indicate that the ability for eelgrass to co-occur and potentially benefit from aquaculture is highly dependent on the site location and inter-annual environmental conditions.

**ECOLOGICAL BENEFITS AND COMMERCIAL PRACTICALITY OF CALIFORNIA SEA CUCUMBER BELOW MEDITERRANEAN BLUE MUSSEL AQUACULTURE**

† Pruitt, C.B.*

*Western Washington University*
Interest in the culture of the California sea cucumber *Apostichopus californicus* for both wild stock enhancement and as an aquaculture resource has been growing in Washington State. *A. californicus* is a good candidate for Integrated Multi Trophic Aquaculture (IMTA), where the detritivores are supported entirely on excess waste from existing floating aquaculture operations (e.g. bivalves or finfish). In IMTA, excess nutrients and organic materials are taken up by this secondary trophic level species, providing both environmental benefits and a marketable product. Over the spring and summer of 2020, *A. californicus* size and cage density ($6/m^2$ and $12/m^2$) are assessed for their effect on sea cucumber growth and assimilation potential underneath Mediterranean Blue Mussel *Mytilus galloprovincialis* floating aquaculture in Totten Inlet, Washington State. *A. californicus* consumption and C:N assimilation rates are measured both in lab mesocosm experiments as well as in the field by comparing samples from *A. californicus* and *M. galloprovincialis* fecal matter. *A. californicus* growth rates are determined from biweekly measurement over the five-month field experiment. The importance of understanding the assimilation potential of *A. californicus* is considered within the aquaculture management lens. Growth potential at different *A. californicus* cage density is considered for working practicality alongside commercial mussel aquaculture.

**DEVELOPMENT OF SEAWEED AQUACULTURE TO IMPROVE SUSTAINABILITY OF THE LIVESTOCK INDUSTRY - A CASE STUDY OF RED ALGA *A. TAXIFORMIS* (YOUTUBE)**

Smith, J.E.*; Dishon, G.; Resetarits, H.M.

*Scripps Institution of Oceanography, UCSD*

There is a critical need to reduce methane emissions in the U.S. agricultural industry, as it is responsible for 17% percent of our country’s greenhouse gas emissions. To date the most successful strategy for methane reduction in livestock is incorporating the red alga *Asparagopsis taxiformis* into their diets. Specifically, *A. taxiformis* has been shown to reduce methane emissions in cows and sheep by up to 90% with just a 0.5-2% inclusion rate. Asparagopsis is a red alga known for its ability to store and produce over 100 different secondary metabolites, with the dominant natural product being Bromoform. While this solution has great potential, a review of past in vitro and in vivo studies show that the amount of methane reduction is dependent on the concentration of bromoform within the alga which can be highly variable. This talk will explore the plasticity of bromoform within *A. taxiformis*, along with how changes in bromoform concentration could affect the suitability of the aquaculture industry. We will also discuss the challenges in developing a sustainable, commercial-scale aquaculture system that is able to produce enough Asparagopsis to initially feed the over 2.5 million cows in California.

**Effects of water temperature and tidal emersion on growth of the Pacific Oyster, *Crassostrea gigas*, in a California estuary (YOUTUBE)**

† Shukla, Priya1; Burge, Colleen M. 2; Grosholz, Edwin D. 1

1- Department of Environmental Science and Policy & Bodega Marine Laboratory, University of California, Davis 2- Institute of Marine and Environmental Technology, University of Maryland Baltimore County, Department of Marine Biotechnology, University of Maryland Baltimore, Department of Immunology & Microbiology

Oyster aquaculture is an economically important industry in California that is directly affected by climate change. In Tomales Bay, California, where several growers culture the Pacific oyster, *Crassostrea gigas*, oysters are susceptible to summer mortality syndrome (SMS) as well as Ostreid herpesvirus (OsHV-1), both of which have been associated with increases in temperature. To understand how water and air temperature (when oysters experience tidal emersion) impact the growth of juvenile *C. gigas*, when they are most susceptible to SMS and OsHV-1, we deployed 250
oysters (19 – 25mm in length) in four mesh baskets (n = 1000 oysters per lease) at each of two oyster leases in Tomales Bay. The northern lease (Lease N) is closer to the mouth of Tomales Bay and experiences greater exchange with the Pacific Ocean. The southern lease (Lease S), which is located near the head of the Bay, has greater water residence times and is warmer relative to Lease N. Thus, we expected the oysters at Lease S to experience greater mortality due to increased pathogen load, but grow faster than those outplanted at Lease N. While the oysters at Lease S grew faster, they also experienced less mortality than their counterparts at Lease N. This may be because the oysters at Lease N experienced more tidal emersion, making them more susceptible to desiccation and sublethal heat effects from increases in aerial temperature. Our next step will be to analyze the oyster tissues to determine whether water temperature and/or aerial temperature influences the prevalence of OsHV-1.

Session 33: Special Session: Engineering resilience in kelp forest ecosystems 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**ARTIFICIAL REEFS FOR KELP FOREST RESTORATION: FROM ISOLATED OASES TO CONCRETE RESTORATION OPPORTUNITIES IN HETEROGENEOUS SEASCAPES (YOUTUBE)**
Ferrario, F.†; MacGregor, K †; Johnson, L.E. 1

1- Université Laval, Québec-Océan 2- Department of Fisheries and Ocean Canada

Ecological drivers that threaten the survival and regeneration of kelp forests are being increasingly recognized and understood. However, successful and reliable kelp restoration techniques are not yet well identified. For example, interventions on natural reefs to counter two known major drivers, sea urchin overgrazing and turf expansion, are logistically complicated and difficult to scale up (e.g. urchin culling, clearings). In contrast, artificial reefs are increasingly being used in coastal areas to offset marine habitat loss and enhance temperate reef communities, including kelp beds. Design (e.g., module size) and deployment strategies (e.g., module spacing) are, however, key components for success, especially in the often heterogeneous seascapes of coastal sea floors. Here we describe a successful artificial reef that created an oasis in the ideal conditions of an isolated sandy bottom. Next we experimentally explore how reef proximity to source populations affected urchin colonization rates. Finally, we demonstrate how small-scale seafloor heterogeneity influences habitat use by urchins and affects the likelihood and rate at which urchins find artificial substrata and consume kelp. By integrating the seascapes into the design of artificial reefs, we can ensure their success when deployed in proximity to natural reefs, thereby increasing their potential to become a realistic restoration technique rather than remaining luxurious but isolated “oases”.

**FUTURE PROOFING KELP FORESTS (YOUTUBE)**
Coleman, M.A.†

New South Wales Fisheries, Department of Primary Industries, Australia

Climate change is causing widespread habitat deterioration and destruction and presents one of the biggest threats to species and global ecological function. Underwater kelp forests underpin fisheries and vast economic values along temperate coasts but are declining due to climate change. There is an urgent need to develop novel and proactive solutions to combat, reverse and prevent this habitat loss. I will discuss how genomic data is providing the evidence we need to “future-proof” kelp forest restoration and management under climate change.
SEA URCHIN BEHAVIOR CONTROLLED BY THE DENSITY OF DRIFT: A ONE-CONSUMER, TWO-RESOURCE IN SITU FUNCTIONAL RESPONSE EXPERIMENT

† Randell, Z.H. 1*; Sheridan, C. 2; Carr, M.H. 2; Novak, M. 1

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

All species are subject to population regulation at certain spatiotemporal scales. Recent climate events and subsequent community shifts along temperate rocky reef ecosystems have drawn attention to the processes regulating sea urchins, often with a focus upon sea urchin predators that control rates of sea urchin loss. But sea urchin behavior is also regulated from the bottom-up by resource availability, and our objective with this research was to experimentally evaluate whether sea urchins exhibit a preference between two alternative resources of: (1) live kelp, whole juvenile *M. pyrifera* affixed to the top of paving stones, and (2) drift algae, blades of *M. pyrifera* sifting about on the bottom. In a controlled caging experiment in the waters offshore of Hopkins Marine Station we characterized the density-dependent effects of these two resources upon the relative rates of resource loss. Our results indicate a strong behavioral preference for consuming drift over kelp: when given the choice of both resources, sea urchins prefer to hunker down in cracks and crevices and consume drift, opposed to moving up onto exposed paving stones to graze kelp. Whereas drift consumption increases with the density of drift available, kelp consumption is unrelated to the density of kelp available, and instead is controlled by the density of drift. This innate behavioral and consumptive preference is particularly relevant for kelp forest conservation and restoration, and ought to be considered as an additional tool to modify rates of sea urchin grazing upon live kelp.

HISTORICAL SWINGS IN SEA OTTERS, BUT NOT KELP FORESTS, CENTRAL CALIFORNIA (1820-2020)

Selgrath, Jennifer C. 1*; Pearse, John 2; Carlton, James 3; Watanabe, James 4; Thomas, Timothy 5; Pearse, Vicki 6; Micheli, Fiorenza 4

1- Stanford University | Channel Islands National Marine Sanctuary 2- University of California Santa Cruz 3- Williams College 4- Stanford University 5- J.B. Phillips Historical Fisheries Project 6- Pacific Grove, CA

Historical perspectives of ecosystems are critical for establishing baselines, setting restoration targets, and for predicting impacts from climate change. Longitudinal perspectives can also be used to distinguish novel ecosystem states from variability that has occurred in the past. However, observations and scientific studies of marine life are often episodic and limited to a few years at a time. In an on-going project to reconstruct ecosystem changes in central California, USA, we examine historical changes in kelp forests in the context of local sea otter extirpation and re-establishment, as well as climate variation. We show that while re-established otters did reduce herbivores, there was no significant relationship between otters and kelp because urchins had not limited the extent of kelp. Extensive kelp forests flourished when otters were absent and kelp did not expand after otters returned. When urchin populations remained high for multiple years, the dominant canopy-forming species of kelp shifted from giant kelp (*Macrocystis pyrifera*) to mixed stands of giant kelp and bull kelp (*Nereocystis luetkeana*). We argue that early hypotheses mistakenly attributed kelp deforestation to herbivory, rather than to physiological stress of El Niños and co-occurring stressors. Our findings demonstrate the essential role of historical ecology in setting baselines and restoration targets for a system. Additionally, our findings underscore the importance of accounting for complexity in ecosystem management.
THE CURIOUS WORLD OF SEAWEED: THE ART & SCIENCE OF A FEW SEAWEEDS FROM OUR PACIFIC COAST (YOUTUBE)
Josie Iselin

San Francisco State University/ Loving Blind Productions

Artist Josie Iselin weaves her luminous algal scans together with historical pressings, taxonomic illustrations and cyanotype prints to tell the life histories and the story of how we know what we know about 16 common species of seaweed and kelp from our Pacific Coast. Josie will choose three chapters to highlight (Nereocystis luetkeana, coralline algae and Mazzaella splendens) in her visually sumptuous presentation that also highlights the many women pioneers in the world of phycology and the ongoing narrative about kelp loss and our changing oceans.

CHARTING A COURSE FOR PYCNOPODIA RECOVERY (YOUTUBE)
Heady, W.N.; Eddy, N.; Saccomanno, V.; Dempsey, T.; Gleason, M.G.

The Nature Conservancy

Recent widespread die offs of the sunflower sea star (Pycnopodia helianthoides) caused by Sea Star Wasting Syndrome creates an urgent need for strategic planning to guide the conservation and recovery of the species. Since the disease outbreak, few if any Pycnopodia have been observed in outer coasts from Mexico to Washington, with numbers dramatically reduced throughout its range; many believe prospects for natural recovery in most regions are slim. The potential for extinction of this important predator comes coincident with recent explosions in numbers of purple urchin and bull kelp highlighting a pressing need for concerted strategic action. Here we present a comprehensive pathway for the conservation and recovery of Pycnopodia focused on four main themes: Status of Wild Populations, Population Biology & Ecology, Captive Breeding and Rearing, and Potential Reintroduction. The objective of this pathway is to map out a unifying vision for the recovery of Pycnopodia throughout its range. The conservation pathway lays out a course of key actions towards recovery that may include the development of a captive breeding program and plan for potential reintroduction of the species should reintroduction be deemed necessary and approved by relevant agencies. We identify and prioritize critical gaps and key intervention points along a recovery trajectory. This pathway may be used to build collaborative efforts, guide conservation investments, and align partners for future action points necessary for the recovery of this important marine species.

TOWARDS A CONCEPTUAL FRAMEWORK FOR MANAGING AND CONSERVING KELP FORESTS IN FUTURE OCEANS: A CASE STUDY IN THE SALISH SEA (YOUTUBE)
Jordan A. Hollarsmith 1; Kelly S. Andrews 2; Nicole Naar 3; Samuel Starko 4; Max Calloway 5; Adam Obaza 6; James Selleck 7; Dan Tonnes 8; Emily Buckner 9; Isabelle M. Côté 10; Thomas W. Therriault 11

1- NOAA AFSC / Simon Fraser University 2- Kelly S. Andrews, NOAA Northwest Fisheries Science Center 3- Washington Sea Grant 4- University of Victoria 5- Washington Department of Natural Resources 6- Paua Marine Research 7- Natural Resources Consultant 8- NOAA NFSC 9- University of Washington 10- Simon Fraser University 11- Fisheries and Oceans Canada

Rapid environmental change driven by multiple stressors can require managers to make decisions based on expert knowledge when local data is scarce, such as in the Salish Sea where declining kelp habitat endangers commercially and ecologically important fish and invertebrate species. In this paper, we gathered a focus group of kelp experts in the Salish Sea to identify perceived direct and indirect stressors facing kelp. We then conducted a comprehensive literature review of peer reviewed studies in the Salish Sea and temperate coastal ecosystems worldwide to assess the level
of support for the pathways identified by the experts and identify knowledge gaps to prioritize future research. Our results revealed major research gaps within the Salish Sea and highlight the reliance on expert knowledge for making informed decisions in the region. We found high support for the pathways in the global literature, with variable consensus on the relationship between stressors and responses across studies. Considering the lack of research identified in the Salish Sea, the focus group approach was highly effective for identifying multiple threats to an important ecosystem. We conclude by highlighting priority areas for future research in the Salish Sea, and recommend that expert opinion be increasingly used to make rapid yet informed decisions to prevent ecosystem collapse.

**SUNFLOWER STAR PREDATION RATES ON FED AND STARVED PURPLE SEA URCHINS**

Kobelt, J.N.; Heady, W.N.; Saccomanno, V.R.; Hodin, J; Duggins, D.O.; Gravem, S.A.; Galloway, A.W.E.

1- University of Oregon 2- The Nature Conservancy 3- Friday Harbor Laboratories 4- Oregon State University

The sunflower star (*Pycnopodia helianthoides*) is known for its diverse diet and predatory prowess, and may exert top-down control on benthic communities in regions where it is the primary or only significant predator of sea urchins. Recent declines in both *Pycnopodia* and kelp forests in Northern California and Oregon have highlighted the need for experiments to quantify trophic interactions between *Pycnopodia* and purple sea urchins (*Strongylocentrotus purpuratus*). We used lab feeding experiments at Friday Harbor Labs in the Salish Sea to determine *Pycnopodia* feeding rates and interactions with both kelp-fed and starved purple urchins. We experimentally starved and spawned urchins as a proxy for urchins from ‘barrens’, which are generally poorly fed and largely devoid of nutritious gonads. We used urchins that were fed bull kelp (*Nereocystis luetkeana*) ad libidum as a proxy of well-fed urchins in healthy kelp forests. Our urchin feeding and starvation-spawning regimen caused fed urchins to have more gonad than starved urchins. We quantified feeding behavior of 24 individual stars with a range of sizes (30-50 cm diameter) using 6-day video-recorded feeding trials and y-maze choice experiments. We did not observe differences in *Pycnopodia* feeding rate between starved and fed purple urchins. We documented variation in feeding behavior among individuals and show that in general, *Pycnopodia* consume 0.5±0.25 urchins day^-1^ (mean, SD). This work further quantifies the effects of *Pycnopodia* predation on purple urchins.

**USING UAVS TO MAP AND MONITOR CATASTROPHIC LOSS OF KELP AND INFORM STRATEGIC MANAGEMENT INTERVENTIONS IN NORTHERN CALIFORNIA**


1- The Nature Conservancy 2- Greater Farallones Association 3- University of California, Santa Barbara 4- University of California, Los Angeles 5- Drones for Science 6- Hog Island Oyster Co. 7- California State University, Monterey Bay

A perfect storm of environmental stressors resulted in an unprecedented decline of kelp along the northern coast of California beginning around 2013. Airplane-based aerial survey data collected by the California Department of Fish and Wildlife (CDFW) suggest that bull kelp (*Nereocystis luetkeana*) canopy was reduced by >90% along a 350 km stretch of coastline by 2016. While these data provide a snapshot of annual kelp canopy extent through the initial onset of said stressors, CDFW's most recent survey was in 2016 leaving managers with a large data gap when it comes to...
informing management interventions. To address this gap, unoccupied aerial vehicle (UAV) surveys of kelp canopy were conducted along the coastline of Mendocino and Sonoma Counties in 2019 and 2020, representing the first comprehensive surveys of priority kelp beds in the region since 2016 and the two largest marine resource focused drone surveys ever conducted in California waters - to our knowledge - at nearly 3,000 acres in 2019 and well over 3,000 acres in 2020. The high-resolution (~ 3 cm) data suggest that from 2016-2019 kelp canopy experienced a further net loss of over 85% in representative sites; however, canopy loss was not ubiquitous across sites and some areas experienced an increase in canopy coverage. The 2020 data are being analyzed. In addition to demonstrating a landmark use case for drones in the marine spatial planning and management space, this work illustrates the value of high-resolution spatial data for determining regions of kelp persistence to inform strategic restoration efforts.

The role of microbial symbionts in kelp forest ecosystems

† Weigel, B.L.¹; Pfister, C.A. ²; Mark Welch, J. L. ³; Ramírez-Puebla, S. T. ⁴

¹- Committee on Evolutionary Biology, University of Chicago ²- Department of Ecology and Evolution, University of Chicago ³- Marine Biological Laboratory, Woods Hole, MA ⁴- The Forsyth Institute, Cambridge, MA

Canopy-forming kelps host millions of bacteria on their photosynthetic surfaces, yet we know little about how these microbes impact kelp forest health and productivity. Using 16S rRNA gene sequencing and novel imaging techniques, we demonstrate that the microbiome of the bull kelp, Nereocystis luetkeana, is taxonomically rich and spatially structured at the micron-scale but varies with geographic location and kelp tissue age. While kelp from a healthy kelp forest hosted dense microbial biofilms with >25 million bacterial cells per cm², kelp from a locally declining population had sparse bacterial communities, indicating that low microbial cell density may be a signal of stressed kelp populations. Functionally, the kelp microbiome may interact with the host kelp through the exchange of carbon and nitrogen. Ecological interactions between the kelp microbiome and the host were explored using field experiments with 13C stable isotope tracers, and by searching for key microbial functional genes using metagenomics. N. luetkeana releases an average of 16% of carbon fixed during photosynthesis as dissolved organic carbon, which may provision associated microbes with a persistent source of fixed carbon. In turn, metagenomics suggests that microbes may perform nitrogen cycling functions that could be of importance to the host kelp. Given these important microbial functions, as well as the link between kelp forest health and microbial cell density, we must consider the attributes of a healthy kelp microbiome as another component in our understanding of kelp forest resilience.

Heat stress causes micro-wounds in coral tissue

Traylor-Knowles, N.*

University of Miami, RSMAS

Corals exposed to elevated temperatures causes a phenomenon called bleaching. During bleaching, the symbiotic relationship between the coral host, and the endosymbiotic algal dinoflagellate, Symbiodiniaceae, breaks down. However, during bleaching, damage to the coral host tissue is sustained, and the ability to heal from this can affect a coral's survivability. Unhealed or slow healing wounds can lead to pathogen invasion. I hypothesize that the coral host tissue damage created by bleaching initiates cascades of wound healing factors that maintain epithelial integrity
and these factors contribute to a corals' bleaching resiliency. In this talk, I will present evidence that heat stress causes damage to the coral host tissue and that collagen accumulation, a sign of wound healing, is found at the site of bleaching, within the gastrodermis. I will also present evidence that during the early stages of bleaching, the wound healing transcription factor, Grainyhead, is expressed throughout the gastrodermis, where the cellular and tissue rearrangements occur. I will also discuss the phylogenetics of cnidarian Grainyhead proteins and the implications of their evolution. Overall this work has important implications for coral resiliency in the face of climate change.

DON'T PUSH ME 'CAUSE I AM CLOSE TO THE EDGE: RESPONSES OF TROPICAL FISHES TO MARINE HEATWAVES

Bernal, M.A.; Schunter, C.M.; Munday, P.M.; Ravasi, T.

Marine heatwaves are currently increasing in frequency and intensity due to the effects of global change. For instance, the marine heatwave of 2016 was one of longest and hottest thermal anomalies recorded in the Great Barrier Reef. This led to mass bleaching of coral reefs in the GBR, but the influence on other marine ectotherms, including coral reef fishes, remains relatively unexplored from a physiological perspective. With this in mind, we evaluated the molecular response of five fish species to the 2016 heatwave, using liver transcriptomes. Our results suggest that gene expression was species specific, but there was some overlap in functional responses associated with thermal stress. Most importantly, the mechanisms activated are very similar to those seen in experiments in captivity. There was significant difference in expression between two time points with elevated temperature, suggesting the duration of exposure to warm waters has a strong influence. This study highlights the importance of considering the effects of extreme warming events when evaluating the consequences of climate change on fish communities.

CAN CALIFORNIA'S NETWORK OF MARINE PROTECTED AREAS PROMOTE RESILIENCE TO CLIMATE CHANGE?


While there is growing concern about the effects of climate change on marine ecosystems, including marine protected areas (MPAs), there has also been an interest in understanding the role that MPAs may play in supporting ecological and societal resilience in the face of climate change. California's statewide network of 124 MPAs offers a unique opportunity to research and evaluate the capacity for MPAs to promote resistance and recovery from climate-related impacts. In preparation for the first formal management review of the network in 2022 led by the California Department of Fish and Wildlife, an expert science panel was convened by Ocean Science Trust, in collaboration with the Ocean Protection Council, to explore how California’s MPA network may promote climate resilience. Emerging evidence from the California Current Ecosystem and beyond suggests that protection provided by MPAs, including enhancing biological attributes such as genetic and demographic diversity, intact food webs, and large population sizes, are important in buffering against the impacts of climate change. In this talk, we will share early findings that have emerged from panel meetings, including an overview of what we know about California’s MPA network.
through the lens of climate change, potential resilience mechanisms and supporting evidence, and potential benefits beyond those considered at the time of MPA network designation. Results from this work can offer insights for opportunities to manage MPAs in a way that can maximize the resilience of social-ecological systems to the challenges ahead.

**SNAILS ON THE MENU?: CHARACTERIZING THE RESILIENCE OF AN EMERGING CALIFORNIA SHELLFISH SPECIES TO MARINE HEATWAVES (YOUTUBE)**
† Clare, X.S.*; Hofmann, G.E.

*University of California, Santa Barbara*

California’s kelp forests are one of our planet’s most productive and dynamic ecosystems—supporting large and small-scale fisheries. However, thermal stress induced by marine heat waves (MHWs) has been documented to have impacts on the productivity of coastal ecosystems. There remains to be a limited understanding on how thermal stress will affect economically important shellfish species at early life stages. To fill this gap, I will present my thermotolerance findings on the Kellet’s whelk (*Kelletia kelletii*), an emerging seafood species of temperate California reefs. In this study, I tested the tolerance to MHW temperatures of two early life stages: veligers and hatchlings. By exposing larvae to a range of temperatures (15-38 degrees Celsius) in acute thermotolerance trials (1 hr.) my major findings were that temperatures that induced developmental abnormalities were at a lower temperature than temperatures that caused mortality. In this presentation, I will share some of the first insights into a molluscan shellfish species that shares both habitat and biology with similar species of high ecological and economic value. Finally, I will compare my findings with long-term environmental data collected at the sites where whelks are found. MHWs present conditions that may decrease the quality of performance necessary for larvae to make it through early development. My work highlights the significance in understanding how economically important species respond to MHWs so we may ensure sustainable livelihoods at sea.

**WHAT WE KNOW: CALIFORNIA AQUACULTURE SPECIES AND ENVIRONMENTAL STRESS (YOUTUBE)**

McDonald, A. M.*

*UC Santa Barbara*

Due to global change, ocean conditions are rapidly changing, resulting in hypoxic waters, lower pH, increasing salt content, and extreme climatic events such as marine heatwaves (MHWs). It is vital to understand the potential impacts of environmental stressors that may affect the physiology of aquaculture species, which could impact industry production and local economies. To this end, I conducted a literature survey to determine any knowledge gaps related to the impacts of temperature, hypoxia, and salinity stress on marine invertebrate species that are approved for aquaculture in California. In the analysis, temperature was the most studied stressor, with salinity and hypoxia also being evenly studied. The most studied species overall were the White shrimp, eastern oyster, and Pacific oyster, respectively, which parallels their commercial success in the United States. Studied species’ population origin varied; however, many of the studies were conducted on populations with origins on the Pacific west coast. In the last decade, there have been several MHWs off the coast of California, thus it is vital to have stringent temperature tolerance requirements for approved aquaculture species. Through understanding of tolerances, individual species may be identified as clear “winners” during MHW events, thus making them ideal to keep in sustainable aquaculture systems. Filling these knowledge gaps will contribute to the development of sustainable aquaculture management strategies.
IMPACTS OF PERVERSIVE SUMMER MARINE HEATWAVES ON GREENSHELL MUSSELS AND OTHER AQUACULTURE SPECIES IN NEW ZEALAND (YOUTUBE)
Ragg, N. L. C.1*; King, N. 1; Dunphy, B. J. 2; Watts, E. 1; Hilton, Z. 1; Finnie, B. 1; Fielder, C. 1; Delorme, N. J. 1; Peychers, C. 1; Zamora, L. N. 1

1- Cawthron Institute, New Zealand 2- University of Auckland, New Zealand

Recent New Zealand summers have been accompanied by unprecedented marine heatwaves. Mean coastal sea surface temperature anomalies reached +3.7°C in 2018, with main driving factors attributed to a combination of stable anticyclonic conditions, positive Southern Annular Mode and weak La Niña. New Zealand’s largest aquaculture industry is based upon the on-growing of Greenshell mussels, *Perna canaliculus*, in hanging sea-based culture. With limited husbandry strategies available to mitigate high temperatures, there is considerable interest in methods to capitalize upon biological resilience mechanisms. Genetic potential was considered by characterizing acute (3h) thermostolerance in 43 genetically diverse full-sibling families from a commercial selective breeding programme. The mean 50% mortality temperature (LT50) varied significantly from 28.9 to 31.8°C between Susceptible and Resilient families. The offspring of Resilient parents were more tolerant of chronically elevated temperatures (21 - 23°C for 14 months). Exposing thermostolerant parents to elevated temperatures during sexual maturation also appeared to shift the thermal window of offspring larvae upwards. The combined data suggest that targeted selective breeding and careful treatment of broodstock could offer effective adaptation strategies for the Greenshell mussel industry. The industry now reports the emergence of a ‘summer mortality’ syndrome, which will galvanize efforts to apply the findings of the research described here.

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

AUTUMN CORAL BLEACHING COULD MEAN TROUBLE FOR THE FUTURE OF HAWAIIAN CORAL REEFS (YOUTUBE)
Brush, E.G.; Jones, R.N.; Dilley, E.R.; Hixon, M.A.

*University of Hawai‘i at Mānoa*

Coral bleaching, or the expulsion of symbiotic algae from the tissues of the host coral that can occur when water temperatures stay above a certain threshold for too long, is the greatest threat to coral reefs globally. Models predict that Hawaiian coral reefs will experience severe annual bleaching events by 2040. Prior bleaching events in the Main Hawaiian Islands (MHI) had occurred in 1996, 2014, and 2015 during periods of elevated water temperatures from August to October, but in 2019, elevated temperatures lasted into December. We monitored 357 adult *Pocillopora meandrina* and 377 juvenile *Pocillopora* spp. colonies offshore of Waikiki Beach on the south shore of O‘ahu, an area numerically dominated by pocilloporid corals. Water temperatures at this site remained above the bleaching threshold of 28°C starting in mid-August, continuously for 56 days from September to October, and did not abate until mid-December. Bleaching stress was evident in 96% of adult colonies, with 4% of those bleaching fully during November and 11% dying by March 2020. In contrast, only 20.7% of juvenile colonies exhibited bleaching stress, yet 47.4% of these died. These mortality rates were lower than documented during previous bleaching events in Hawai‘i, but the later than normal timing of this event is of great concern. Should bleaching events continue to occur later in the year when coral reefs would normally be recovering from elevated summer temperatures, the increased stress may further exacerbate the effects of ocean warming and the ability for coral reefs as we know them to persist.
DETERMINING RESPONSE AND RECOVERY OF RED ABALONE, HALIOTIS RUFESCENS, TO MARINE HEATWAVES (YOUTUBE)
† Chiachi, A.E.†; Barnas, D.M; Silbiger, N.J

California State University, Northridge

Anthropogenic warming has caused extreme heatwaves to become more frequent and severe, and as a result, many coastal fisheries, such as the Cultured Abalone in Goleta, CA, are likely to be negatively impacted. Because of the high cost of maintaining seawater conditions, abalone aquaculture facilities often pump water directly offshore, leaving stock susceptible to these natural environmental fluctuations. In order to improve production efficiency, aquaculturalists use size-class grading to organize abalone for market sale, leaving a gap in knowledge of understanding how marine heatwaves will affect the growth and physiology of individual size classes of red abalone. Using realistic heatwave data from the previous 10 years in Goleta, CA, we investigated the relationship between extreme marine heatwave events and their effect on three size classes of red abalone. We measured growth, body mass condition index, and respiration rates before, during, and after a heatwave trial. Our results can help strategize best management for red abalone fisheries and conservation practices in the future.

CO-DESIGNING RESEARCH TOWARDS IDENTIFYING THE HIDDEN IMPACTS OF CLIMATE CHANGE ON CANADA'S UNDERSEA FORESTS (YOUTUBE)
Denley, D.E.1*; Salomon, A.K. 1; Frid, A. 2

1- Simon Fraser University 2- Central Coast Indigenous Resource Alliance

In addition to gradual warming, more frequent and intense marine heat waves (MHWs) associated with climate change pose a substantial threat to coastal marine ecosystems. In 2015 during an unprecedented MHW in the northeast Pacific Ocean, First Nations Coastal Guardian Watchmen on the Central Coast of BC observed an expansive outbreak of an encrusting bryozoan, Membranipora spp., with giant kelps becoming so heavily encrusted that they sank to the seafloor and disintegrated. This concerned First Nations communities, who rely heavily on kelp forest ecosystems for commercial, food, social and ceremonial purposes. Climate change is threatening food security for coastal nations world-wide, causing them to seek solutions to maintain access to traditional foods and other marine resources. In partnership with the Central Coast Indigenous Resource Alliance, we co-designed this project to examine the effect of increasing ocean temperature on interactions between this epiphytic bryozoan and its kelp host. Preliminary data on the seasonal timing and abundance of bryozoan on kelp suggests that wide-spread outbreaks may be delayed or moderated in years with cooler spring temperatures. However, isolated outbreaks still occurred in individual kelp beds, highlighting the importance of local-scale adaptive management strategies. Outcomes of this project will inform community-based management of kelp harvest and related fisheries to minimizing negative impacts of temperature-induced bryozoan outbreaks and increase the resilience of both kelp forests and coastal communities to climate change.

THE 2018 SOUTHERN CALIFORNIA BIGHT MARINE HEATWAVE (YOUTUBE)
Fumo, J.T.1*; Carter, M.L. 2; Flick, R.E. 2; Rasmussen, L.L. 2; Rudnick, D.L. 2; Iacobellis, S.F. 2

1- University of Hawaii 2- Scripps Institution of Oceanography

In early August 2018, record-high sea surface temperatures were recorded in the 102 year old Scripps Institution of Oceanography daily temperature time series (SIOT) at La Jolla, CA, USA. The previous record of 25.8 °C, set in July 1931, was broken four times over 9 days, peaking at 26.4 °C
on 9 August 2018. Optimum Interpolation Sea Surface Temperature data suggest that the marine heatwave (MHW) manifested in the northern half of the Baja California Peninsula, tapering off into the Southern California Bight. Here we use the Optimum Interpolation Sea Surface Temperature data to categorize this MHW as severe with relatively high maximum intensity (3.9 °C) and long duration (44 days) when compared to other events in the time series. Glider profiles show that the thermal anomaly was largest near the surface and extended to at least 100 m depth. By detrending the SIOT to remove the long-term anthropogenic climate signal and comparing the resulting data set to the unadjusted, we contextualize this MHW with respect to the entire time series and demonstrate that the long-term trend played a crucial role in amplifying the intensity and duration of the MHW. In this case, the anthropogenic warming signal in the SIOT accounts for an additional 19 MHW days (from 24 to 43) and an increase in cumulative intensity of 56.8 °C (from 83.1 to 139.9).

**LATITUDINAL VARIATION IN SEAGRASS WASTING DISEASE IN THE NORTHEAST PACIFIC**

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1- Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY 2- School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA 3- Institute of Marine and Environmental Technology, University of Maryland, Baltimore, MD 4- Seagrove Kelp Co, Ketchikan AK 5- Department of Computer Science, Cornell University, Ithaca, NY 6- Department of Zoology, University of British Columbia, Vancouver, BC 7- Hakai Research Institute, Calvert Island, BC 8- NOAA Northwest Fisheries Science Center, Seattle, WA 9- Department of Sociology, University of Central Florida, Orlando, FL

Eelgrass *Zostera marina* is a foundation species that creates critical coastal habitats worldwide and fulfills essential ecosystem functions. Currently, eelgrass meadows are threatened by anthropogenic and environmental stressors, including seagrass wasting disease *Labyrinthula zosterae*. Infection can lead to mass mortalities and have cascading ecological and economic impacts. However, large-scale patterns of disease and linkages to environmental conditions remain unclear. To address this knowledge gap, we surveyed disease in paired subtidal and intertidal eelgrass meadows spanning from Alaska to Puget Sound, WA in the summers of 2017 and 2018. From measuring disease in 5,536 eelgrass blades, we show that disease varied significantly between latitudes, tidal regimes, and years, with elevated disease levels in the warmer of the two years; ocean temperatures and salinity were also found to be closely linked to disease prevalence and severity. Our study is novel in that it provides a valuable time-series analysis of seagrass wasting disease across a broad latitudinal and temporal range and across tidal regimes. Understanding broad-scale patterns of disease and environmental drivers of wasting disease outbreaks has the potential to inform key decisions regarding eelgrass conservation along the West Coast, USA.

**ECOSYSTEM SHIFTS IN THE WESTERN STRAIT OF JUAN DE FUCA 2011 TO 2019-FROM KELP DOMINATED SYSTEMS TO URCHIN BARRENS**

Larson, S.*; Christiansen, J.; Olsen, A.; Tanz, A.; Randell, Z.

*Seattle Aquarium*

The Outer Coast of Washington is rugged, remote, and home to a rich and varied assembly of species. In particular, temperate rocky reefs ecosystems, often associated with kelp forests, play an important role in providing food, shelter, or nursery habitat for macroalgae, invertebrates, fishes,
and marine mammals. In an effort to understand marine ecosystems in the Outer Washington Coast, and forecast future patterns of change, biological and physical monitoring are in place by federal, non-profit and tribal agencies. The Seattle Aquarium has been monitoring five reef systems in the western Strait of Juan de Fuca for 15 years. Using SCUBA based underwater video transects we have documented significant changes in fish assemblages, sea stars, understory kelp cover, and abundance of sea urchins. Notable ecosystem shifts were documented over the years shifting from those dominated by understory kelps and sea stars between 2011-2014 to bare rocks, few sea stars and an increase in urchins between 2015-2019. Concordant with this shift was an increase in rock species from interannual variability between 2005-2013 to steady increase after 2014. This ecosystem shift is thought to be associated with the warm water anomaly in the Northeast Pacific, “the blob”, between 2014-2016 that precipitated the sea star wasting events allowing for increased growth of sea urchin populations with an associated decrease in kelps. These data highlight the importance of long-term monitoring of marine ecosystems to better understand species interactions.

THE EFFECTS OF A RECENT MARINE HEATWAVE ON THE SEA PALM POSTELSIA PALMAEFORMIS (YOUTUBE)
Lohse, DP; Raimondi, PT; Ammann, KN

University of California, Santa Cruz

Populations of the sea palm “Postelsia palmaeformis” have been monitored annually since the early 2000’s at several sites along the California and Oregon coast. While abundances at all sites varied over time, in 2015 all monitored populations decreased dramatically (87-100%). This decline coincides with the manifestation of the 2014-2016 marine heatwave (MHW) that impacted the western coast of North America. During this MHW sea surface temperatures 2 – 3 degrees C above normal were recorded at the study sites; at the southernmost sites SST exceeded 18 degrees C. Since 2015 recovery has been low at most sites, particularly in the south. There has also been an increase in cover of the competitively dominant mussel “Mytilus californianus”, which has potentially hindered recovery.

EFFECTS OF MARINE HEATWAVE CONDITIONS ACROSS THE METAMORPHIC TRANSITION TO THE JUVENILE SEA URCHIN (HELIOCIDARIS ERYTHROGRAMMA) (YOUTUBE)
Maria Byrne 1*; Mailie Gall 2; Sebastian Holmes 2; Hamish Campbell 1

1- The University of Sydney 2- Western Sydney University

As the incidence and duration of marine heatwaves (MHW) increases, for fast developing species, such as the sea urchin Heliocidaris erythrogramma, the entire planktonic duration can be impacted. The thermal tolerance of development of this ecologically important Australian endemic through metamorphosis to the established juvenile was investigated over a broad temperature range (7.6-28 °C), including levels experienced across its distribution and MHW conditions. At control temperatures (19.5-21.0 °C) 80% of individuals developed to metamorphosis at day 5 and this doubled to 10 days at 14.0 °C. The thermal range (14.4–21.2 °C) of metamorphosis on day 7 reflected the realised thermal niche of H. erythrogramma and the upper temperature for 40% success (T40) was 25.9 °C (+5 °C). By day 10 the optimal temperatures and T40 for the juveniles narrowed to the local range (16.2–19.0 °C, 25.0 °C), similar to warming levels tolerated by adults. Reduced tolerance indicated negative carryover effects across the metamorphic transition and cumulative effects of MHW conditions. In the absence of phenotypic adjustment or adaptation, regional warming will be detrimental, although populations may be sustained by thermotolerant
offspring. Our results show the importance of the metamorphic transition in understanding the cumulative sensitivity of marine species to MHW

**IMPACTS OF HEAT STRESS ON SOFT CORALS, AN OVERLOOKED, BUT FUNDAMENTAL COMPONENT OF CORAL REEF ECOSYSTEMS** (YOUTUBE)
† Maucieri, D.G.; Baum, J.K.

*University of Victoria*

Global climate change is threatening the persistence of reefs, with recent heat stress events causing unprecedented levels of coral bleaching and mortality. Reviewing the literature published in the last five years that had documented the effects of the third ever global coral bleaching event (2014-2017), we found that minimal studies examining heat stress effects on corals included soft corals (20%; 19/94), or quantified the effects of the heat stress event on soft coral communities (15%; 14/94). We then examined the factors influencing soft coral cover before the 2015-2016 El Niño event on Kirimiti island (central equatorial Pacific Ocean) and quantified the effect of the heat stress event on soft coral cover using benthic cover in small photoquadrats. On Kirimiti, soft coral cover was affected by the region of the atoll before the heat stress event, with site exposure and the local human disturbance interacting to affect soft coral cover. The heat stress event had a significant effect on soft coral cover and caused almost entire eradication of soft corals (99.7-100% cover loss), however, in 2019, new recruits were seen on the reefs, suggesting hope for new soft coral growth and recovery of soft coral communities. Additionally, permanently established photoquadrats show that soft corals do not degrade as much as previously believed, but some leave behind a structure that can persist for many years. We conclude that soft corals are incredibly vulnerable to heat stress, and should be studied more to better understand how these communities are being affected.

**SEASONAL DYNAMICS OF MULTIPLE CORAL SPECIES FROM REEFS WITH STABLE AND VARIABLE THERMAL REGIMES** (YOUTUBE)
† McRae, C.J. 1; Keshavmurthy, S. 2; Chen, H.K. 3; Ye, Z.M. 3; Rosset, S. 4; Meng, P.J. 3; Huang, W.B. 5; Chen, C.A. 2; Fan, T.Y. 6; Côté, I.M. 7

1- Simon Fraser University & National Dong Hwa University 2- Academia Sinica 3- National Museum of Marine Biology and Aquarium 4- Victoria University of Wellington 5- National Dong Hwa University 6- National Museum of Marine Biology and Aquarium & National Dong Hwa University 7- Simon Fraser University

Multiple local and global stressors have led to the degradation of coral reefs globally, impacting essential ecosystem functions and services. Climate change-induced ocean warming is primarily responsible for the recent increase in frequency and intensity of mass coral bleaching events. Species traits and reef site characteristics are known to influence coral response to warming, yet high variability in responses has been observed even within species. In an effort to explain this variability we monitored individual coral colonies seasonally for one year at two reefs sites with distinct thermal regimes (stable vs. variable) in southern Taiwan. We assessed the coral and symbiont physiology at both sites for three species with different life-history strategies: *Pocillopora acuta* (weedy life history), *Acropora nana* (competitive life history), and *Porites lutea* (stress-tolerant life history). Preliminary results show differences in maximum quantum yield (a measure of symbiont photochemical performance) and lipid class proportions across species and sites; interestingly, differences were not consistent across seasons. Further, we assessed the bleaching resistance of these colonies in summer 2020 during the most severe bleaching event observed in Taiwan. *Acropora nana* and *Pocillopora acuta* colonies bleached and had higher mortality at the stable reef site, whereas *Porites lutea* had high bleaching resistance at both sites. Future work will
assess the role of Symbiodiniaceae genotype on coral performance across sites, species, and seasons.

**A SINGLE HEAT STRESS BOUT INDUCES RAPID AND PROLONGED HEAT ACCLIMATION IN THE CALIFORNIA MUSSEL, MYTILUS CALIFORNIANUS (YOUTUBE)**
† Moyen, NE; Crane, RL; Somero, GN; Denny, MW

*Hopkins Marine Station of Stanford University*

Climate change is causing not only steady increases in average global temperatures but also increasing the frequency with which extreme heating events occur. Thus, it is important to understand how quickly an organism’s heat tolerance can be gained and lost, relative to the frequency with which extreme heating events occur in the field. We show that the California mussel, *Mytilus californianus*—a sessile intertidal species that experiences extreme temperature fluctuations and cannot behaviorally thermoregulate—can quickly (in 24-48 h) acquire improved heat tolerance after exposure to a single sublethal heat-stress bout (2 h at 30 or 35°C) and maintain this improved tolerance for up to 3 weeks without further heat exposure. This adaptive response improved survival rates under extreme heat stress bouts (2 h at 40°C) by ~75%. To interpret these lab findings in an ecological context, we evaluated 4 y of mussel body temperatures recorded in the field. This rapid heat acclimation is beneficial as the majority (~64%) of consecutive heat stress bouts are separated by 24-48 h. However, the ability of *M. californianus* to maintain improved heat tolerance for up to 3 weeks after a single sublethal heat-stress bout significantly improves their probability of survival, as ~33% of consecutive heat events are separated by 3-22 days. As a sessile animal, mussels likely evolved the capability to rapidly gain and slowly lose heat tolerance to survive the intermittent, and often unpredictable, heat events in the intertidal zone.

**WIDESPREAD DECLINES IN CANOPY-FORMING KELP (MACROCYSTIS PYRIFERA AND NEREOCYSTIS LUETKEANA) ALONG A LOCAL 2.5°C GRADIENT IN SST (YOUTUBE)**
Neufeld, C.J.1; Starko, S. 2

1- Bamfield Marine Sciences Centre 2- Department of Biology, University of Victoria

Kelps play fundamental roles in nearshore ecosystems around the world and drive coastal productivity. Kelps are optimally adapted to temperate environments and have therefore experienced negative consequences in response to ocean warming in many parts of the world, including along the west coast of North America. Barkley Sound, a large geographically complex region with more than 1000 km of linear shoreline ranging from wave-exposed outer-coast sites to shallow wave-sheltered bays, is an ideal study system to evaluate the impacts of environmental drivers, like temperature, on kelp forest resilience, in isolation from anthropogenic stressors. To evaluate how recent broad-scale stressors have influenced the two main surface-canopy-forming kelp taxa (*Macrocystis pyrifera* and *Nereocystis luetkeana*) in this region, we: i) measured spatial variation in sea-surface temperature, ii) resurveyed several observational datasets collected over the past 25 years, and iii) monitored kelp condition and morphology (e.g. blade length, growth, condition, epiphyte cover) in a subset of local populations. We found that summer sea surface temperatures from the outer coast inwards vary by almost 2.5°C, and that kelps showed site-specific declines in occupancy and condition, with surface canopy populations further into the sound performing poorly overall. To our surprise, we found relatively large and healthy non-floating *Macrocystis pyrifera* growing along the bottom further into the sound and suggest that these ‘prostrate’ populations may serve as important deep-water refugia.
WARMING AND INTERSPECIFIC INTERACTION BETWEEN A NON-INDIGENOUS AMPHIPOD AND ITS CONGER (YOUTUBE)

Parretti, P.1*; Ros, M. 2; Gestoso, I. 3; Ramalhosa, P. 3; Costa, A.C. 1; Canning-Clode, J. 3

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The increase of ocean temperature and the establishment of non-indigenous species (NIS) have profound implication for marine biodiversity as they can, both individually and in concert, have dramatic impact on the structure and function of native communities. To evaluate the impact of successful invasions of marine ecosystems by NIS in a future climate change scenario, we analysed how an increase in temperature may affect interference competition (i.e. displacement) between two ecologically similar caprellid species that co-occur in the Portuguese Atlantic archipelago of Madeira: the NIS Caprella scaura (Templeton, 1836) and its congener Caprella equilibra (Say, 1818). We conducted a mesocosm experiment to assess the interaction between the two species and the effects of warmer ocean waters on this interaction. Specifically, we investigated the effect of an increase in temperature on i) survivorship and interspecific displacement when C. scaura and its congener coexisted at similar densities, and ii) survivorship and interspecific displacement in the two species when the density of NIS is higher compared to C. equilibra. Furthermore, we explored differences in the heart rate of the two species as proxy for physiological condition. Our results showed that in a future scenario of ocean warming for Madeira Island (29ºC), survivorship of the two caprellids species most likely will not be affected. While, the displacement of the resident C. equilibra will be influenced by a combination of temperature and density of NIS.

Symbiont fidelity and evolutionary dead ends in the face of prolonged marine heatwaves

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Marine heatwaves disrupt the vital relationship between corals and their symbiotic algae, leading to bleaching and often mortality. Increasing evidence suggests that corals with tight host-symbiont relationships may be less likely to bleach. However, tight associations with symbionts may be risky, if particular symbionts are poorly suited to extreme conditions, risking an evolutionary ‘dead end’. In this study, we track tagged colonies of Porites lobata through a tropical heatwave of unprecedented duration. P. lobata has vertical symbiont transmission, leading to an association between symbiont and host genotypes. While all colonies were generally dominated by C15-type symbionts, ‘weak’ sequence variants were associated with more rapid bleaching and 3-fold lower survival than ‘strong’ symbiont profiles, an effect that was significant even after accounting for host relatedness. Differential mortality across hosts with distinct symbionts led to a change in the overall genetic structure of the host population. However, a small number of colonies with weak symbiont genotypes fully bleached, experienced partial mortality and then recovered with a strong genotype. Patterns of symbiont switching further reinforced patterns of differential survival, such that strong symbionts increased drastically in their relative frequency. Although our results are consistent with the hypothesis that symbiont fidelity can lead to dead-ends in the face of extreme environments, the
potential for symbionts and hosts to recombine under extreme conditions may limit the extinction of lineages.

**INTRA- AND INTER-ANNUAL VARIATION IN A CENTRAL CALIFORNIA ESTUARY SETTLEMENT COMMUNITY FROM 2012 - 2020: ENSO, PDO AND HEAT WAVES** *(YOUTUBE)*

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1- Center for Coastal Marine Sciences, Cal Poly San Luis Obispo 2- Statistics Department, Cal Poly San Luis Obispo

The settlement of marine organisms can vary over multiple temporal scales, influenced by fluctuations in seasonal oceanographic conditions and broad-scale oceanographic processes like El Niño and the Southern Oscillation (ENSO). The eastern Pacific Ocean experienced a trifecta of oceanographic changes in 2014 – 2016, including a state shift in the Pacific Decadal Oscillation (PDO), numerous marine heat waves, and an ENSO event. Previous work has examined the intra- and inter-annual variation in marine settlement communities but few studies have examined settlement communities from central California estuaries before, during, and after the oceanographic changes observed from 2014 – 2016. Cal Poly has assessed the marine settlement community in Morro Bay, California as part of a broader marine coatings research project since 2012. We measured the percent cover of organisms on PVC settlement plates, deployed on a monthly cycle, and tested the settlement taxa relative to season and several oceanographic indices that quantified broad-scale oceanographic processes (e.g. ENSO, PDO). The Morro Bay settlement community experienced intra-annual variability related to seasonal oceanographic patterns; there were additional inter-annual taxonomic changes related to oceanographic indices. This study adds to our understanding of marine settlement community dynamics in estuaries by providing insight into settlement variability related to seasonal and large-scale oceanographic fluctuations.

**ECOSTRESS: 50-M RESOLUTION TEMPERATURE MEASUREMENTS FROM THE SPACE STATION FOR COASTAL AND INTERTIDAL THERMAL ECOLOGY** *(YOUTUBE)*

Wethey, D.S.*; Weidberg, N.; Woodin, S.A.

*University of South Carolina

The ECOSTRESS thermal infrared radiometer on the Space Station has a spatial resolution of 50 – 60 m and a return time of hours to 5 days, depending on geographic location. It measures water and land surface temperature at spatial scales approximating patch sizes of organisms and the scale of intertidal aquaculture operations. It also resolves details of oceanographic features not detectable in imagery from MODIS or VIIRS. We calibrated ECOSTRESS surface temperature observations against imagery from VIIRS and geosynchronous satellites, the NOAA in-situ SST Quality Monitor archive of ocean drifter data, and a network of intertidal temperature sensors on the coast of Europe. ECOSTRESS ocean temperatures have a consistent 1.5 to 1.0 °C negative bias relative to other satellite and in-situ measurements, based on comparison of VIIRS and ECOSTRESS pixels and matching in-situ and geosynchronous SST observations to ECOSTRESS pixels. We applied this bias correction to all SST and intertidal surface temperature data from ECOSTRESS. ECOSTRESS measured fine scale gradients in low tide temperature of 7-8°C between the high and low tide lines on intertidal shellfish beds 2 hours after sunrise in summer in NW Spain. Similar spatial gradients were measured on the surface of the water at high tide in late afternoon after the incoming tide was heated by the sediment. Such differences help explain the intertidal distribution of commercially harvested clams in the region, where the most thermally sensitive species are restricted to the low intertidal or to levels deep in the sediment.
TORTOISE AND HARE: FLEXIBLE EARLY GROWTH STRATEGIES IN A NEARSHORE FISH MAINTAIN RECRUITMENT SUCCESS IN A VARIABLE ENVIRONMENT (YOUTUBE)
† Wilson, M.N.*; Grorud-Colvert, K.; Sponaugle, S.

Department of Integrative Biology, Oregon State University

Marine fishes are known to experience upwards of 90% mortality during their earliest stages in the pelagic ocean. Starvation, predation, and advection from suitable habitat exert strong selection pressures on individual early life history traits that confer survival through this treacherous period. Understanding the biological and oceanographic factors that modulate this mortality gauntlet is key to predicting fish population dynamics, especially as they relate to socio-economically important fish stocks and changing ocean conditions. In conjunction with the Oregon Department of Fish and Wildlife Marine Reserves program, we used Standard Monitoring Units for the Recruitment of Fishes (SMURFs), to quantify patterns of recruitment of nearshore groundfishes along the Oregon coast for 8 years (2012-2019). We used otolith microstructure analysis to quantify larval and juvenile growth rates for a fish species, cabezon (*Scorpaenichthys marmoratus*), that recruits in multiple events throughout each recruitment season. This extended recruitment window coupled with seasonal variability in the Northern California Current, provided the opportunity to assess the relationship between variable ocean conditions, growth rate, and successful recruitment. Our results demonstrated that cabezon early growth patterns varied within and among years in relation to oceanographic conditions. Such a plastic life history strategy may enhance the resilience of the cabezon population to large-scale disturbances such as the 2014-2016 marine heat wave.

CHANGES IN KRILL BODY SIZE DURING THE 2014-2016 EASTERN PACIFIC MARINE HEATWAVE
Ian Brown¹; Helen Killeen ¹; Jeffrey Dorman ²; William Sydeman ²; Connor Dibble ³; Steven Morgan ¹; Sadie Small ¹

1- Coastal & Marine Sciences Institute, UC Davis 2- Farallon Institute 3- Scoot Science

Climate-driven warming of surface waters has caused significant changes in many aquatic ecosystems as well as the organisms that inhabit them. In pelagic ecosystems, krill are vulnerable to increases in sea surface temperature, which have a nonlinear effect on the overall growth of aquatic arthropods. Krill are a dominant food source for many species, so changes in krill body size due to surface warming have the potential to create a bottom-up effect on their many predators. We monitored krill body size in the California Current during a period of high variability in sea surface temperature including the Warm Blob marine heatwave from 2014-2016. Krill were collected as part of the annual NOAA-NMFS Rockfish Recruitment Ecosystem Assessment Survey, and were sampled from the inner and outer shelf off the California coast. Individual krill were measured and identified to sex and species. Krill body lengths varied in relation to temperature with species-specific differences. One species showed an increase in average length as temperatures rose (*Nematocelis difficilis*), another species decreased in average length (*Thysanoessa Spinifera*). A third species showed a non-linear response (*Euphausia Pacifica*). These results show that changes in marine sea surface temperature are likely to alter available krill biomass through impacts on krill body size with consequences for coastal food webs. However, understanding species-specific differences in krill response to climate change will be important to predicting population and ecosystem level impacts of warming.

Session 36: Community Ecology 3
* indicates presenting author, † indicates eligibility for Best Student Paper Award
SPATIAL PARTITIONING IN CORAL-REEF FISHES THAT DO NOT COMPETE *(YOUTUBE)*

† Jones, R.N.*

*The University of Hawaii at Manoa*

Coral reefs around O’ahu, Hawai‘i are largely dominated by cauliflower coral (*Pocillopora* spp.), whose highly complex branching structure provides habitat for a variety of fishes and invertebrates. Two fish species that commonly inhabit these colonies are the Galactic Scorpionfish (*Sebastapistes galactacma*) and the Speckled Scorpionfish (*S. coniorta*). These species occur in overlapping depth ranges: Galactic Scorpionfish deeper and Speckled Scorpionfish shallower. In the zone of overlap (reefs 4-9 m deep), these fishes inhabit coral colonies in close proximity to one another, occasionally co-occupying the same colony. Because these two species appear to be ecologically similar, interspecific competition could be limiting their abundances on reefs where both are present. To test this hypothesis, I conducted reciprocal press removals of each species within clusters of coral colonies and followed the abundances of each in the presence and absence of their putative competitor. If competition is limiting the abundance of one or both species, then removal of the congener should result in an increase in the abundance of the remaining species. This expected pattern was not observed, and abundances of both species were nearly unchanged following the removal of their congener. This outcome indicates that competition is not presently an important interaction between these species, possibly due to recruitment limitation. Future studies will analyze the diets of both species to determine the extent of dietary overlap, testing for possible partitioning of food resources.

ADDRESSING THE COMPLEXITIES OF CORAL BLEACHING STUDIES AND HIGHLIGHTING THE NEED FOR STANDARDIZATION ACROSS MEASUREMENTS *(YOUTUBE)*

† Khen, A.*; Smith, J.E.

*Scripps Institution of Oceanography, UC San Diego*

The majority of today’s coral reefs are projected to decline due to ocean warming, thermal anomalies, and coral bleaching events associated with global climate change. Nevertheless, coral responses have been known to vary depending on factors such as geographic location, coral taxon, colony size, morphology, and/or prior bleaching history. Long-term observational measurements of bleaching, recovery, growth, and mortality are important because they allow for the documentation of variability within and among individual corals through time. Although the scientific community has developed valuable tools for predicting, detecting, and measuring coral bleaching, certain limitations remain which make it difficult to compare results across studies. By standardizing the ways in which we quantify (and perhaps even define) coral bleaching, we will be able to track responses more rigorously and accurately. This would give us better insight into corals’ differential bleaching and mortality susceptibilities, and may also have implications for reef management and conservation.

ABILITY OF INTERTIDAL CANOPIES TO AMELIORATE ABIOTIC CONDITIONS *(YOUTUBE)*

Knapp, C.L.*; Zabin, C.J.; Chang, A.L.

*Smithsonian Environmental Research Center, San Francisco State University*

Intertidal macroalgal canopies attenuate thermal stress caused by emersion, providing potential microhabitats that could benefit species threatened by desiccation and heat stress. The San Francisco Bay Living Shoreline Project at Giant Marsh has the goal to study the ability of canopies to engineer ecosystems, specifically the potential effects of canopy on the Olympia oyster, *Ostrea lurida*, a restoration target sensitive to long exposure to warm air temperatures. The rockweed
Fucus distichus is found in the intertidal zone throughout San Francisco Bay, and is the target macroalgal species for the Giant Marsh restoration project. Initial transplants at Giant Marsh were not successful, motivating this study to provide more information on the abiotic conditions underneath macroalgal canopies and artificial materials that could mimic this during low tides. We measured temperature and relative humidity underneath Fucus and other canopy types over 10 days. Conditions under Fucus canopy were found to be about 8°C cooler and 36% more humidity compared to no canopy, and provided a greater attenuation effect than another macroalgal species, Mastocarpus sp. We found that terrycloth could replicate the conditions underneath Fucus as a potential mimic, if attempts to transplant Fucus are not successful. Proving its ability to ameliorate conditions during low tides, restoration of Fucus could offer microhabitats that are less thermally stressful to Olympia oysters. This offers an opportunity to make intertidal habitats more resilient in the face of climate change.

**USING REMOTELY OPERATED VEHICLE DATA TO DETERMINE DIETARY SPECIALIZATION IN SIPHONOPHORES**

† Lapides, A.E. ¹; Damian-Serrano, A. ²; Choy, C.A. ³; Dunn, C.W. ²; Haddock, S.H.D. ¹

**1- Monterey Bay Aquarium Research Institute (MBARI) 2- Yale University 3- Scripps Institution of Oceanography**

The open-ocean midwater represents the largest habitat on the planet. However, we still have little understanding of the trophic connections that comprise the midwater food web. Siphonophores are abundant and diverse predators which likely play important roles in structuring this system. With the advent of submersible technologies it is increasingly feasible to observe both siphonophores and their potential prey in situ, allowing us to make high-quality predictions of their abundance and distribution. Using observations from MBARI’s underwater video database (the Video Annotation and Reference System aka VARS), we built generalized additive models of each siphonophore and each potential prey concept and quantified the predicted spatial-temporal overlap between each pair. We then compared these overlap measurements with the frequencies of observed feeding events to determine the predatory specializations of various siphonophores. Using this method we determined 10 of the 17 siphonophores investigated were dietary specialists. Reconstructing these trophic links enhances the resolution of midwater food web models and improves our knowledge of this understudied habitat.

**EXCLUSION OF CONSUMERS LEADS TO LESS PREDICTABLE CORAL REEF BENTHIC COMMUNITIES (YOUTUBE)**

† McDevitt-Irwin, J.M ¹; McCauley, D.M. ²; Micheli, F. ¹

**1- Stanford University 2- University of California Santa Barbara**

Disentangling how communities assemble after disturbances is integral to our understanding of community structure and predicting community states. As communities form, they can converge (low beta diversity) or diverge in community state (high beta diversity). Coral reef benthic community assembly is strongly regulated by benthic feeding fishes, but little is known about how these consumers influence longer term community state and overall beta diversity. In addition, these fishes are declining on coral reefs worldwide. Here, we aim to further our understanding how benthic feeding fish influence the diversity and assembly of coral reef benthic communities over time. We deployed 180 paired terracotta tiles, caged (excluding large fishes) and uncaged, and surveyed species composition at one year and three years after deployment, on coral reefs at Palmyra Atoll, in the Pacific Ocean. Overall, our preliminary results show that the caged tiles have increased beta diversity and diverge in community state during assembly. Specifically, the uncaged
tiles converge on a community state typically dominated by CCA whereas the caged tiles have less predictable community states (e.g. dominated by Lobophora, CCA, or turf). Our preliminary results suggest that when reefs lose benthic feeding fish, this leads to a more unpredictable benthic community, that is no longer necessarily dominated by CCA. As coral reefs continue to reassemble after relentless disturbances, it’s imperative we consider that as we lose benthic feeding fishes, we may also lose predictability in our benthic communities.

**INTERSPECIFIC FUNCTIONAL DIFFERENCES IN BIOTURBATION AND NUTRIENT PROVISIONING BY CARIBBEAN SEA CUCUMBERS** (YOUTUBE)
† Munger, R.B.*; Dunic, J.; Watkins, H.; Côté, I.M.

*Simon Fraser University*

Sea cucumbers perform important ecological functions in coral reef ecosystems, including the provision of ammonium through metabolic excretion, and the renewal of sediment layers through bioturbation of reef sands. Estimating rates of energy and material movement at an ecosystem level requires fine scale determination of functionality on a species level. Are sea cucumber species functionally interchangeable or does sea cucumber diversity enhance reef functionality? We addressed this question by quantifying and comparing ammonium excretion and bioturbation in situ by co-occurring *Holothuria mexicana* and *Actinopyga agassizii* in a Caribbean patch reef ecosystem. We found that rates of both excretion and bioturbation were species specific, but only varied marginally with body size. We used these species-specific functional rates to estimate excretion and bioturbation at 35 reef sites across Rock Sound, the Bahamas. Although *H. mexicana* excreted approximately 23% more ammonium and bioturbated approximately 53% more sediment per hour than *A. agassizii*, differences in abundance between the two species resulted in larger reef-wide contributions to both functions by *A. agassizii* across sites. This suggests that despite unique empirical measures of functionality provided by each species, sea cucumber density plays a larger role in the ecosystem processes of nutrient provisioning and bioturbation.

**EXPANDING THE GRAZER REVERSAL HYPOTHESIS: UPWELLING AND CONSUMPTIVE EFFECTS ON BENTHIC DIVERSITY** (YOUTUBE)
Munson, C.J.1*; Greenhill, M. 2; Lamb, R.W. 2; Witman, J.D. 2

1- University of California Santa Cruz, Brown University 2- Brown University

The grazer-reversal hypothesis predicts that plant diversity will be decreased by grazers in low nutrient conditions and unaffected in high nutrient conditions. We tested this hypothesis in the Galapagos subtidal and hypothesized that it applies to not only macroalgae, but the entire sessile benthic community due to competition for space and similar responses to nutrient inputs between sessile invertebrates and macroalgae. We used caging experiments and recruitment tiles to investigate the response of benthic diversity to the combined effects of upwelling-derived nutrients and consumption. Our results show that the grazer reversal hypothesis applies to both macroalgae and sessile invertebrates together: at low and intermediate upwelling sites with relatively few bottom-up inputs, consumer effects on biodiversity were stronger and negative. In contrast, there were no significant consumer effects at the high upwelling site, suggesting that strong upwelling overrides consumption in structuring benthic communities. Based on a paradoxical result that filamentous algae were more abundant in the open compared to the caged treatment at the high upwelling site, we suggest a new subtidal mechanism for the grazer-reversal hypothesis: damselfish may increase algal diversity at high upwelling sites by selectively removing competitive dominants. In the context of global change, it is crucial to understand the interplay between bottom-up and top-
down processes to conserve and effectively manage biodiversity and the ecosystem functions it provides.

Session 37: Conservation and Restoration 3
* indicates presenting author, † indicates eligibility for Best Student Paper Award

MAPPING OYSTERS ON THE PACIFIC COAST OF NORTH AMERICA: A COASTWIDE COLLABORATION TO INFORM ENHANCED CONSERVATION (YOUTUBE)
† Perog, B.D.1; Kornbluth, A.2; Crippen, S.3; Zacherl, D.C.1; Wasson, K.4

1- California State University, Fullerton 2- Pew Charitable Trusts 3- University of California, Riverside 4- University of California, Santa Cruz

The Olympia oyster (Ostrea lurida) was historically abundant in estuaries from British Columbia to Baja California but was over-harvested in the late 1800s to early 1900s. The non-native Pacific oyster (Crassostrea gigas) was introduced to supplement the aquaculture industry and has become established in many estuaries. Restoration efforts are underway in many estuaries to support recovery of the Olympia oyster. All of these initiatives have had a local focus, and until now there has been no comprehensive synthesis of historic and current Olympia oyster distribution. We worked with oyster experts from three countries and completed comprehensive literature and iNaturalist searches to map past and current wild populations of the Olympia and Pacific oyster. We collected 2,281 records from a combination of 172 researchers, 20 organizations, and 339 iNaturalist observations. Analyses will explore temporal and spatial patterns in oyster distributions, oyster network size, substrate type, and estuary characteristics relevant to oyster abundances. Restoration practitioners can enhance conservation strategies using these data by targeting restoration efforts that expand oyster connectivity, by understanding where the Olympia oyster is currently absent or rare versus where they were historically abundant, and by understanding where the Pacific oyster thrives. Our work highlights the capability to build comprehensive maps of both non-native and native species using crowd-sourced data.

ANALYSIS OF LOS ANGELES COASTAL DUNES PGPR AND THEIR POTENTIAL EFFECTS ON CROP PLANTS (YOUTUBE)
† Shen, E.1; Lum, M. 2

1- Biology, Loyola Marymount University 2- Loyola Marymount University

The El Segundo Dunes is the site of a former residential community which now is the largest remaining plot of coastal dunes in Southern California, spanning 302 acres and providing refuge to over 900 species. Of particular interest are PGPR (Plant Growth Promoting Rhizobacteria), bacteria that associate with the roots of plants and are beneficial in regulating the soil environment and creating optimal environments for plant vitality and restoration. The objective of this study is to characterize and identify common PGPR that can be associated with native dune plants. Trap plant experiments with Escholzia californica, Lupinus bicolor, Camissoniopsis cheiranthifolia with El Segundo Dunes soil and bacteria were isolated from the rhizosphere/nodules of plants. Data was collected from over 120 PGPR isolates. Isolated strains underwent biochemical analyses for PGPR properties such as nitrogen fixation and cellulase activity; 16S rDNA analysis was done to identify bacterial strains. A majority of the PGPR found come from the Proteobacteria phylum, with the genera Rhizobium and Pseudomonas dominant. Firmicutes, comprised of the genus Bacillus, were also prevalent. Among species of plants, variation was seen with amount and type of PGPR associated. This work aids in understanding the relationships of species of plants and microbes and may give insight on how the Dunes can be preserved and restored to its past conditions. Future
experiments will involve introducing these strains while seeding the Dunes in order to get an in-depth analysis on their effects.

RESTORED OYSTER REEFS RAPIDLY MATCH FUNCTIONS OF NATURAL REEFS (YOUTUBE)
Smith, R.S. 1*; Lusk, B. 2; Castorani, M.C.N. 1

1- Department of Environmental Sciences, University of Virginia 2- Virginia Coast Reserve, The Nature Conservancy

Oysters provide valuable ecosystem services in coastal habitats, but populations are considered functionally extinct worldwide due to overfishing and development. To reverse oyster losses, restoration projects have increased exponentially since 1990, despite unknown recovery timelines and undefined assessments of restoration success. We performed a 15-year experimental study to measure the function of restored and natural reefs in coastal Virginia. Eastern oyster (Crassostrea virginica) abundance and biomass on restored reefs increased rapidly and matched reference reefs in just six years; abundance of a dominant resident mesopredator also reached equivalence in six years. Temporal stability of oyster populations increased with oyster biomass, suggesting that restoration can stabilize ecosystem processes. We demonstrate that restored oyster populations can rapidly match natural reefs and increase the ecological function of these imperiled coastal ecosystems.

THE MPA GUIDE: A SMART SOLUTION FOR EFFECTIVE OCEAN PROTECTION (YOUTUBE)
Sullivan-Stack, J.*; Grorud-Colvert, K.; Lubchenco, J.

Oregon State University

Marine Protected Areas (MPAs) are a ubiquitous and well-studied tool for managing and conserving marine biodiversity. They are important for coastal communities and management in regions such as the California Current, and also play a key role in international agreements. For example, UN Sustainable Development Goal 14 and Aichi Target 11 call for protecting 10% of the ocean in MPAs and Other Effective Area-Based Conservation Measures by 2020, and there is current momentum to increase these targets to at least 30% of the ocean by 2030. However, conversations around MPAs are often rife with confusion. Basic information is unclear, such as how much protection currently exists, how effective it is, and how much more is needed to meet international or community-based goals for ocean conservation. Here we present The MPA Guide, a framework and common language to clear up this confusion. It has four core elements: (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 categorizes an MPA or zone by how well it protects biodiversity and habitats from abatable human extractive or destructive activities; (3) Enabling Conditions, or the important social and ecological considerations that are prerequisites for effective MPAs; and (4) Outcomes for human well-being and conservation that can be expected from an MPA at a given Stage and Level, if Enabling Conditions are met. Thus, The MPA Guide facilitates clear categorizing, tracking, evaluating and planning of MPAs.

SUBLETHAL EFFECTS OF SIMULATED CLIMATE CHANGE CONDITIONS ON WHITE ABALONE, HALIOTIS SORENSENII (YOUTUBE)
Tjeerdema, E.R. 1*; Swezey, D.S. 2; McNealy, J.L. 1; Kawana, S.K. 1; Souza, C.A. 3; Marshman, B.C. 3; Sanford, E.D. 4; Moore, J.D. 3; Aquilino, K.M. 5

1- UC Davis Bodega Marine Laboratory 2- UC Davis Bodega Marine Laboratory & The Cultured Abalone Farm 3- UC Davis Bodega Marine Laboratory & California Department of Fish and Wildlife
Restoration efforts for endangered species are often faced with the challenges of climate change, and white abalone (Haliotis sorenseni) are no exception. An understanding of how the impending oceanographic changes in temperature and pCO₂ will combine with Candidatus Xenohaliotis californiensis (CaXc; a ubiquitous abalone intracellular parasite) infection to impact the survival, growth, and feeding rates of H. sorenseni is vital for the captive breeding and wild restoration efforts for this species. In this study, we exposed three year old H. sorenseni to factorial combinations of 12, 15, and 18°C seawater crossed with pCO₂ levels of 600 and 1100µatm (low and high CO₂, respectively), and presence or absence of CaXc infection for 300 days. We found that reduced growth in body mass and shell length were attributable to high CO₂ alone, as well as interactions between initial size, CaXc, and temperature. The condition index (a metric for abalone health) was significantly decreased by both high CO₂ and temperature. In feeding trials, an interaction between temperature and CaXc reduced consumption of Macrocystis pyrifera, a primary food for captive H. sorenseni. These findings suggest that increasing pCO₂ and heat stress pose a significant challenge for H. sorenseni production and restoration, particularly in combination with CaXc infection. We recommend further investigation of the effects of these stressors, adaptation strategies for captive breeding, and a careful examination of optimal locations for the outplanting of captive-raised individuals.

Crabitat: Assessing habitat-specific variation in distribution and abundance of juvenile blue crabs in a large lagoonal estuary
† Voigt, E.P.¹; Eggleston, D.B. ²

1- Dept. of Marine Earth and Atmospheric Science, North Carolina State University 2- Center for Marine Sciences & Technology, North Carolina State University

Nursery habitats promote the survival of juveniles to the adult population and are often targeted by conservation policies. Managers must choose where to focus efforts, which is complicated when juveniles utilize multiple habitats. This is particularly applicable to the NC blue crab (Callinectes sapidus) population, which utilizes: (i) two main juvenile habitats, seagrass and shallow marsh detrital habitat (SDH), (ii) different coasts of the Albemarle-Pamlico estuarine system (APES), and (iii) different life stages. Understanding how these habitats function in terms of juvenile crab density and distribution is important given that the blue crab population in NC has demonstrated significant decreases in juvenile recruitment and spawning stock since 2000. In this study, we quantified habitat-specific variation in distribution and abundance of blue crab instars (2.2- 20mm) over time. Blue crab density was highest in seagrass habitats followed by SDH when measured adjacent to well-established postlarval, pelagic dispersal corridors. Juvenile crabs were concentrated in seagrass near major inlets connecting Pamlico Sound to the Atlantic Ocean, and distributed broadly along the western shore of Pamlico Sound, which is dominated by SDH. The data so far suggests that expansive SDH along the western shore of Pamlico Sound be considered as effective juvenile habitat for early juvenile blue crabs.

ASSESSING DRIVERS OF GENETIC DIVERSITY ON CORAL REEFS (YOUTUBE)
Dellinger, R.J.¹; Rumberger, C.A. ²; Bay, R.A. ³

1- University of California, Davis (1st presenting author) 2- University of California, Davis (2nd presenting author) 3- University of California, Davis
Coral reefs in the Anthropocene face a profound decline from a culmination of global and local threats. Genetic diversity can serve as the raw material for adaptation, buffering species from the effects of such stressors, yet large-scale surveys between and across species of coral are lacking. Therefore, it is essential to assess the drivers of genetic diversity and its consequences for recovery. Here we compile a global database of genetic diversity from microsatellites in species of Acropora, the largest coral genus. We use expected heterozygosity as a measure of diversity, and compare this to both species trait and spatial environmental data to uncover the drivers of this diversity. Preliminary analyses show that pH and species’ upper depth limit are the variables most strongly associated with genetic diversity. Additionally, we find that the Caribbean Acropora palmata has unexpectedly high genetic diversity, the highest of any Acroporid species. These findings suggest that there is evidence for species-specific genetic diversity levels and that abiotic factors and anthropogenic induced stressors may influence the genetic diversity of the genus Acropora. Considering the importance of genetic diversity amongst populations, management strategies can utilize the information of allelic diversity to generate an assessment of large-scale ecological change.

**ORIGIN AND PERVERSIVENESS OF THE PESTIFEROUS LAND SNAIL THEBA PISANA (GASTROPODA: HELICINIDAE) IN SOUTHERN CALIFORNIA**

Vendetti, J.E.1; Sandig, K. C. 2; Sahakyan, A. 2; Simonyan, S. 2; Granados, A. 3

1- Natural History Museum of Los Angeles County, Los Angeles, CA 2- Glendale Community College, Glendale, CA 3- Williams College, Williamstown, MA

The terrestrial white Italian snail, *Theba pisana* is a known invasive outside of its native European and circum-Mediterranean range. In Southern California it has a 100-year history of establishing dense populations in Los Angeles and San Diego counties. Here we used Natural History Museum of Los Angeles County specimens and freshly collected *T. pisana* snails from both counties (e.g. coastal Palos Verdes peninsula, Los Angeles Co. and San Elijo coastal wetlands, San Diego Co.) and compared their mtDNA CO1 barcoding sequences with a rich dataset from the GenBank and BOLD databases. Los Angeles-collected *T. pisana* were genetically distinct from those collected in San Diego and shared a CO1 haplotype with *T. pisana* from the Mediterranean island of Malta, whereas San Diego-collected specimens shared a haplotype with *T. pisana* from Morocco. *Theba pisana* in Southern California has, therefore, been introduced multiple times from different source populations. Further study of these snails from other sites where they have been introduced and become established can reveal additional insights about their invasivity and dynamics of their introduction.

**Session 38: Ecosystem Assessment 1**

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

**Communicating Ecological Status with Interactive Infographics**

Benjamin D. Best1; Jennifer Brown 2; Tylar Murray 3; Su Kim 4; Chris Caldow 5; Pike Spector 5; Jai Ranganathan 6; Ellen Spooner 7; Gabrielle Canonico 8; Enrique Montes Herrera 3; Frank Muller-Karger 3

1- EcoQuants LLC, Santa Barbara, CA, USA 2- ECOS Consulting LLC, Lafayette, CA, USA 3- College of Marine Science, University of South Florida, St Petersburg, FL, USA 4- NOAA Fisheries, Northwest Fisheries Science Center 5- NOAA National Marine Sanctuaries 6- National Center for Ecological Analysis & Synthesis, Santa Barbara, CA, USA 7- ECS Federal in support of NOAA IEA, Fairfax, VA 8- NOAA U.S. Integrated Ocean Observing System
In order to inform timely management and communicate to a wide audience, indicators of marine ecological status and trends should be made available in a readily accessible format and updated as soon as newer data becomes available. Initially as a Marine Biodiversity Observation Network (MBON) project serving the Florida Keys and Monterey Bay National Marine Sanctuaries, we developed an interactive infographic framework (using D3 JavaScript, R and Rmarkdown software) to link elements (e.g., species, climate and human) in an ecosystem illustration to popup windows of interactive maps and time series, which are automatically updated based on the latest available data. The websites are hosted by Github and updated using the Github Actions – all of which is free for a reasonably sized website (< 1 GB) and minimal computation for updating (< 1 hr). We are expanding this product to other sanctuaries and NOAA’s Integrated Ecosystem Assessment program. All software is free to use and code is open-source.

**Turbidity limits the role of kelp forests in carbon storage and assimilation**

Blain, C.O.\*; Shears, N.T.

*University of Auckland*

Kelp forests are rapidly gaining recognition as important contributors to marine carbon cycles and sequestration. Despite this, relatively little is known about the production and fate of carbon originating from these highly productive ecosystems, or how anthropogenic and climate related stressors effect the role of kelp in marine carbon cycles. Here, we examined the impact of increasing turbidity on the carbon storage, fixation and loss in southern hemisphere kelp forests. We quantified net primary production (NPP), biomass accumulation (BA), and estimated carbon release via detritus and dissolved organic carbon (DOC) across a large-scale turbidity gradient. We show how increased turbidity, and reduced light, limits the vertical distribution and productivity of kelp, which ultimately reduces the potential role of these ecosystems as donors to coastal carbon cycles. When averaged annually, estimates of NPP and BA at high light sites were nearly 6 and 2 times greater than that at low light sites, respectively. Carbon fixed annually by kelp forests was up to 4.7 times greater than the carbon stored as standing stock. At low light sites the majority of C goes directly into tissue growth and is subsequently eroded. In contrast, excess production at high light sites, which is likely released as DOC, accounts for up to 39% of the total carbon fixed. These results highlight the high productivity and turnover of carbon through kelp forests, while demonstrating the significant impacts of turbidity on both the quantity and fate of carbon fixed.

**MAPPING BULL KELP FORESTS OF PUGET SOUND WITH CONSUMER-LEVEL UAV IMAGING PLATFORMS**

\*Cowdrey, T.J.\*; Berry, H.D. \*; Calloway, M.D. \*; Ryan, A.T. \*

1* The Evergreen State College 2* Washington State Department of Natural Resources

Bull kelp (*Nereocystis luetkeana*) is an important primary producer in Puget Sound that occupies a critical niche in local marine ecosystems. Kelp beds provide essential functions such as the dampening of wave energy, fixing nutrients in vegetative tissue, and creating habitat for diverse species of invertebrates, fish, and marine mammals. Over the past decade, evidence of the decline of bull kelp within Puget Sound has led to renewed interest in establishing robust long-term monitoring protocols for this species. Traditional boat-based survey methods provide rich and detailed datasets but are also time and resource intensive. Unmanned aerial vehicles (UAVs) present a compelling opportunity to complement these methods with the ability to rapidly collect remote sensing data over large areas. For this project, eight kelp forest sites were surveyed a total of 18 times over the course of the 2020 summer season using a DJI Mavic 2 Pro carrying a Hasselblad 20MP 1" CMOS RGB camera sensor. In collaboration with the WA Department of Natural Resources.
Resources, ten of these aerial surveys were conducted concurrently with boat-based data collection to provide real-time ground-truthing. Initial efforts to create geospatially accurate orthomosaics using photogrammetric software show promising results, though the bulk of image processing will occur this fall and winter. Based on the results of this study, WADNR will be assessing the efficacy of implementing a UAV-based monitoring protocol of bull kelp for all of Puget Sound as a tool in state conservation and restoration efforts.

**INTERACTIVE VISUALIZATION OF MARINE INTERTIDAL TEMPERATURES** *(YOUTUBE)*
† Dobbelaere, C.M.; Chamorro, J.D.; Hofmann, G.E.

**UC Santa Barbara**

Given global climate change and an associated increase in the frequency and duration of marine heatwaves, accessible widespread communication of such trends remains a crucial goal in marine science, both for public awareness and informed management. The rocky intertidal zone, along the U.S. West Coast, is a dynamic ecosystem that has been documented to be particularly vulnerable to climate warming, primarily because many of the organisms that it supports live near the boundary of their thermal tolerance. We have developed an interactive online platform via R Shiny to visualize long-term temperature records captured by Robomussels, biomimetic temperature loggers, at marine intertidal research sites along the U.S. Pacific Coast. Thermal timeseries data were compiled from the Helmut Lab (Northeastern University), the Partnership for Interdisciplinary Studies in Coastal Oceans (PISCO), and the Multi-Agency Rocky Intertidal Network (MARINe). This platform was designed to have an interactive, user-friendly interface that allows users to easily visualize and comprehend data, making it a valuable resource for research, education, and outreach.

**DIVERSITY AND DISEASE OF MOBILE BENTHIC FAUNA IN FLORIDA BAY AFTER CYANOBACTERIA BLOOMS DEGRADE HARD-BOTTOM HABITAT** *(YOUTUBE)*
† Duermit-Moreau, E.1*; Bojko, J. 2; Behringer, D. 1

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Shallow, hard-bottom habitat covers ~30% of Florida Bay and is designated as an Essential Fish Habitat for commercially fished teleosts and invertebrates. It is dominated by a diversity of sponges, which give structural complexity to the otherwise low-relief habitat. This habitat and its many ecosystem functions can become severely impaired after periodic cyanobacterial blooms. The direct and indirect effects of these blooms on the commercially important Florida stone crab *Menippe mercenaria* and Caribbean spiny lobster *Panulirus argus*, and their diseases, remain broadly unknown. These species are affected directly by habitat loss (sponge die-off), but indirect effects due to potential lack of prey and upon their local epidemiology remain understudied. In the summer of 2019, we surveyed three healthy sites and three degraded sites (sites hit by blooms) in Florida Bay. We used transects to quantify the structural differences across the habitats and collected benthic fauna by suction sampling to explore changes in biodiversity. Up to 30 *M. mercenaria* and *P. argus* were hand collected from each site and were screened to discern their individual pathogen profiles. The results include the detection of ‘*Panulirus argus* Mininucleovirus’ in *P. argus* and a trophically transmitted gregarine in *M. mercenaria* that may use local fauna to transmit. This study increases our understanding of the ongoing changes in Florida Bay from epidemiological and biodiversity perspectives in response to cyanobacterial blooms.
GLACIAL INFLUENCE ON HIGH LATITUDE ESTUARIES (YOUTUBE)
Konar, B.1*; Munk, L.A. 2; Veazey, P. 1

1- University of Alaska Fairbanks 2- University of Alaska Anchorage

Fire and Ice: Navigating Variability in Boreal Wildfire Regimes and Subarctic Coastal Ecosystems is a 5-year effort by Alaska NSF EPSCoR to conduct research into changes to fire risk and behavior in Alaska’s boreal forest, and changes to physical and chemical variables that influence biological communities in the nearshore Gulf of Alaska. The goal of the Coastal Margins team is to evaluate the impacts of large-scale ocean drivers and climate-driven landscape changes on glacial and non-glacial fed estuaries along the Gulf of Alaska, and to provide information that supports improved resource management and community resilience. Researchers focus on the causes and impacts of changes to freshwater discharge into the Gulf, which have major effects on coastal ecosystems and key economically and culturally important species. They combine fieldwork on opposite sides of the Gulf of Alaska in Kachemak Bay and Lynn Canal with climate modeling, laboratory work, surveys and analysis of existing data to address their research questions.

ECOLOGICAL DRIVERS OF SEAWEEDS IN THE GULF OF CALIFORNIA (YOUTUBE)
† Montalvo Jaramillo, L.M1*; Cortés Fuentes, C. 1; Ramírez Ortiz, G. 2; Reyes Bonilla, H. 1

1- Departamento Académico de Ciencias Marinas y Costeras, Universidad Autónoma de Baja California Sur 2- Programa de Ecología Pesquera, Centro de Investigaciones Biológicas del Noroeste.

Seaweeds as primary producers and biogenic structures are important trophic and habitat resources for multiple reef taxa, but their coverage and composition is also determined by abiotic (physical and chemical) and biotic factors (herbivory). We aimed to analyze the effect of these factors to determine seaweed coverage in 30 reefs of the Gulf of California. Underwater visual censuses (100 m^2 transects) were performed to record six algal groups: brown, filamentous, green, red, articulated and crustose coralline algae. Species richness, abundance and size of herbivorous fish were also registered, to later calculate their density and biomass. The abiotic factors considered were latitude, longitude, and depth (m; in situ); phosphate, nitrate, and silicate concentration (mg/m^3; World Ocean Atlas); sea surface temperature (ºC), light attenuation coefficient (nm) and irradiance (W/m^2; GIOVANNI). Generalized additive models were built to describe non-linear relationships between predictors (abiotic and biotic factors) and coverage of each algal group. Geographic longitude (>20% of deviance explained) and light (irradiance and attenuation; >18%), had major effects in brown and articulate coralline algae coverage, while the density of herbivores had significant effect in filamentous and green algae. Coralline crustose and red algae presented a combined effect of abiotic and biotic factors, but irradiance and depth presented the major effects (>30%). In general, the coverage of the six algal groups were mostly influenced by abiotic factors, and herbivory played a secondary role.

SURVEYING HOW CANADIAN MARINE MANAGERS INCORPORATE CUMULATIVE EFFECTS IN DECISION-MAKING (YOUTUBE)
† Orofko, M.1*; Curren, G. 2; Therriault, T. W. 3; Fanning, L. 2; Côté, I. M. 1

1- Earth to Ocean Research Group, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada 2- Marine Affairs Program, Dalhousie University, Halifax, NS, Canada 3- Pacific Biological Station, Fisheries & Oceans Canada, Nanaimo, BC, Canada

Cumulative effects from multiple stressors are increasing in marine ecosystems. The effectiveness of ecosystem management can be improved by incorporating cumulative effects, including three key elements: varying stressor interaction types (i.e. synergistic, additive, and antagonistic), non-
linear effects of stressors on ecosystems, and ecosystem tipping points. Little is known about how cumulative effects are incorporated into marine ecosystem management in Canada, so we surveyed Canadian federal government managers of marine conservation areas and commercial marine fisheries to determine the extent to which cumulative effects are incorporated into decision-making. We found that most (84%, n=81) respondents do consider cumulative effects in their decision-making. Also, despite most (97%, n=37) respondents believing that interaction types, non-linear stressor effects, and tipping points are important to consider, only 21% (n=37) do consider all three of these key elements. This suggests that barriers to their incorporation are not linked to disbelief of their importance; instead, other possible barriers include data availability, quantity, and quality. Our results provide a snapshot of how cumulative effects are currently incorporated in Canadian marine ecosystem management. The will to include key elements of cumulative effects in decision-making exists, but more must be done to identify and remove barriers to doing so.

Session 39: Intertidal Ecology 4
* indicates presenting author, † indicates eligibility for Best Student Paper Award

Aggregations of marine benthic animals cause steep oxygen gradients inside their colony: The cost of living together (YOUTUBE)
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Fluctuations in oxygen levels have been typically studied on a large scale in marine systems. However, at far smaller spatial scale a couple of studies have also demonstrated that benthic species are capable of generating low oxygen micro-environments. Yet, oxygen levels inside their colonies or aggregations have been poorly characterized. Under laboratory conditions, we measured the oxygen levels inside the colonies and aggregations, from the core to the edge using Hydrozoan, Ophiurioiids and Porcelain crabs as model species. Also minimum oxygen pressure at which this species is capable of maintaining efficient aerobic respiration ($P_{Crit}$) was determined for each specie. The results indicate the existence of steep oxygen gradients in all aggregations. The oxygen levels decreases from the edge, becoming almost anoxic (lower than 10 mmHg), in the inner zone of the aggregations of the colonies. Their $P_{Crit}$ values of ranged from $7.47 \pm 0.43$ mmHg in bryozoans to 43.6 ± 4 in ophiuroids; and considering $PO_2$ levels in the core that were lower than their $P_{Crit}$, a variable proportion of the colony’s organisms are living under physiologic stress (~50% in the most extreme case). Living in groups is a behavioral strategy that brings benefits, but it can also bring physiological stress to a large percentage of the population since their physiological resistance can be exceeded by the micro environmental conditions, generated by their lifestyle. Further research is needed to understand de physiological consequences of this phenomena.

INFLUENCES OF HERBIVORES, TEMPERATURE, AND NUTRIENTS ON MARINE MICROBIAL ASSEMBLAGES: RESULTS OF AN IN-SITU EXPERIMENT (YOUTUBE)
† Lees, L.E.; Bracken, M.E.S.
University of California Irvine

While the importance of nutrient cycling between macrofauna and microbes in pelagic systems is well recognized, the interactions between herbivores and benthic biofilms are often ignored in intertidal systems. Herbivores have consumptive effects on benthic microbial growth, but they also alter local nutrient availability and algal recruitment on rocky shores, potentially influencing microbial diversity and functioning. We expect these interactions to change as water temperatures
rise, herbivore abundance changes, and nutrient dynamics shift. To assess the impact of herbivores on intertidal benthic microbial communities, we experimentally manipulated herbivore density, temperature, and nutrient concentrations in 24 tide pools in the Bodega Marine Reserve, California. In each tide pool, we installed tiles as a substrate for microbial recruitment. Half of the tiles in each tide pool were caged to limit consumption of the biofilm, while allowing nutrients to pass freely through the mesh. At the completion of the experiment, we collected samples from the tiles for microbial community analysis using 16S rRNA and 18S rRNA. By identifying and characterizing the benthic microbial communities in these environments, we can begin to understand the influences of consumers, temperature, and nutrients on microbial diversity.

INVASION OF THE BODY SNATCHERS: PARASITES ALTER BEHAVIOUR AND MORPHOLOGY OF AN INVASIVE SNAIL [YOUTUBE]
† Lim, E.G.1; MacLeod, C.D. 2; Heese, B. 3; Harley, C.D.G 2

1- Simon Fraser University 2- University of British Columbia 3- Vancouver Island University

Introduced species often display altered behaviour in new environments, but the extent to which interactions are maintained when two interacting species are introduced together is unknown. We investigated an invasive host-parasite pair in a novel habitat to examine how behavioral and morphological control of the host by the parasite varies between these species’ native and introduced ranges. We found that Japanese mud snails (Batillaria attramentaria) infected with trematode parasites (Cercaria batillaria) were more likely to be found lower in the intertidal at 9 of 10 beaches we surveyed in the Salish Sea, but at one site, Page Lagoon, this trend was reversed. Our in situ growth rate experiment revealed that infected snails grow faster and reach a larger maximum size than uninfected snails. Infected snails also moved toward the lower intertidal at 2 of the 3 beaches where we marked them, but again this trend was reversed at Page Lagoon. These morphological and behavioral effects are assumed to increase parasite reproduction and transmission, and extend the range of B. attramentaria into the lower intertidal. Further, reversed trends in lagoon snails hint at an effect of salinity on infected snail behaviour, as salinity-driven currents differ between Page Lagoon and the other sites. Our results are largely in line with similar studies from the native range of B. attramentaria, but opposite trends at Page Lagoon caution against assumptions that invasive parasites will affect their invasive hosts similarly in introduced ranges.

MEASURE MUSSELS TWICE, CUT ONCE: COMPARING RESULTS OF MANIPULATIVE EXPERIMENTS TO LONG-TERM OBSERVATIONS IN THE ROCKY INTERTIDAL [YOUTUBE]
† MacAdams, C.A.; Bachhuber, S.M.; Gravem, S.A.; Menge, B.A.

Oregon State University

In well-studied habitats, insight into large scale ecosystem processes can be gained from comparisons between long-term observational datasets and shorter-term manipulative experiments. Underlying mechanisms can be challenging to discern from long-term data, while experiments based in theory may be impossible to maintain long term. We compared two datasets, one from a 5-year series of observations and one from an 18-month experiment, to better understand the impacts of Sea Star Wasting (SSW) on mussel bed dynamics in the Oregon and northern California rocky intertidal. The observational data are mussel bed measurements from 2013-2019, gathered to document how the beds changed post-SSW. The experimental data measures biomass of mussel recruits in cages with four treatments (Nucella ostrina only, Leptasterias spp. only, both predators, and no predators), designed to determine the effects of Nucella and Leptasterias in the absence of keystone predator Pisaster ochraceus. We ask whether
the observed change in mussel beds corresponds to the impact of these compensatory predators at 4 rocky intertidal sites at Capes Foulweather, Perpetua, Blanco, and Mendocino. Preliminary results indicate that both bottom up (primarily the supply of mussel and barnacle recruits) and top down (predation by *Pisaster* and the two compensatory predators) control play an important role in determining mussel bed spatial distribution. Understanding the broader ecological context of experimental data is an increasingly important aim in a rapidly changing anthropocene ocean.

AN UNDESCRIBED AND WIDESPREAD TREMATODE INFECTION REDUCES THE REPRODUCTIVE OUTPUT OF A MARINE FOUNDATION SPECIES

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*University of British Columbia*

Parasitic infection often results in reduced host reproductive output (RO), the key fitness metric in all species. However, direct measurements of these effects in the field are often confounded by biotic or abiotic variables unrelated to the presence of parasites. In 2019, we discovered that approximately 80% of acorn barnacles (Balanus glandula) in Burrard Inlet, Vancouver BC, were infected with an unidentified trematode parasite, and that infection intensity varied substantially over short distances. Given the high density of barnacles in this habitat and the important ecological role that this species plays, any parasite-mediated reduction in RO could represent an important but previously overlooked regulating determinant of community structure in the Inlet. We compared the RO of barnacles from two nearby sites that exhibited high and low mean parasite infection rates but were otherwise biologically and physically similar. Reproductive output, calculated as the ratio of brood mass to somatic tissue mass, was 15-29% lower at the high infection site, primarily indicating that parasitic infection could reduce the density of this foundational species. Given the high barnacle densities observed throughout Burrard Inlet, however, it is more likely that the effects of reduced RO will be indirect. Barnacle larvae are an important food resource for many species, and the reduced RO caused by infection could limit planktivore population size. Thus, parasites may represent a major, undetected regulating force in the community structure of Burrard Inlet and other similar habitats.

THE EFFECTS OF A HABITAT-FORMING ALGA ON ENVIRONMENTAL CONDITIONS AND COMMUNITY COMPOSITION

† Mahanes, S.A.*; Bracken, M.E.S.; Sorte, C.J.B.

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Habitat-forming species can play a critical role in structuring ecosystems by producing complex structures and affecting community composition. Additionally, these species may alter local environmental conditions and have different effects on individual associated species or functional groups. We studied *Neorhodomela oregona*, a turf-forming alga which is abundant at our study site in southeast Alaska, to assess its effects on pH, temperature, and community composition in tide pools during a three-month time period in the summer of 2019. We conducted a removal experiment on *Neorhodomela* in 10 total tide pools and an algae addition mesocosm experiment with 8 total mesocosms. We measured the rate of change of pH in the tide pools and mesocosms with time-series water samplings, measured temperature with data loggers, and conducted biodiversity surveys to assess changes in the community. We found that higher amounts of *Neorhodomela* resulted in more rapid acidification during the night but did not affect the rate of pH change during the day. We did not find an effect of *Neorhodomela* on temperature. *Neorhodomela* removal reduced the abundance of *Littorina* snails, the most numerous invertebrates at the site, in the weeks following the treatment. *Neorhodomela* removal also caused a temporary increase in
producer abundance, suggesting that *Neorhodomela* may be competitively limiting other producers. Future research could investigate the mechanisms of interaction between *Neorhodomela* and *Littorina* as well as test the effects of *Neorhodomela* on pH across seasons.

**PATTERNS OF ABUNDANCE AND POPULATION SIZE STRUCTURE OF SEA URCHIN *PARACENTROTUS LIVIDUS* ON THE CENTRAL COAST OF PORTUGAL**

Mateus D.¹; Carvalho C.A. ²; Maresca F. ¹; Alves C. ¹; Jacinto D. ¹; Catro J.J. ³; Costa J.L. ⁴; Cruz T. ³

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*Paracentrotus lividus* is a common echinoid species on intertidal and shallow subtidal rocky shores of the NE Atlantic. It plays an important ecological role and its importance as an economic resource has increased during the last years, namely along the central coast of Portugal. Our goal was to study the spatial variability in abundance and size structure of *P. lividus* and habitat availability along the central coast of Portugal, and to provide for the first time a stock assessment (urchins >5cm test diameter) for the study region. Two habitats were considered: tidepools and shallow reefs (<2m deep). During summer 2020, surveys were carried out along the ~100km that comprise the study region, considering 3 areas (10’s km apart), 2 sites per area (100’s m apart), and 4 transects (10’s m apart) per site. Estimates of abundance and size structure were obtained by counting and measuring sea urchins in replicated sampling units (n=6 quadrats). Habitat availability was estimated from low-altitude (~30m) high-resolution drone imagery. Estimates of stock abundance and biomass were obtained by crossing both sources of information. Results suggest highly variable patterns of distribution at multiple spatial scales. The use of drones as a novel method in sea urchin stock assessment studies may provide a low-cost solution for a large coverage of intertidal areas with sufficient detail to map habitat availability and estimate the abundance and biomass of standing stocks, providing information of crucial importance for stakeholders and fisheries management purposes.

**DIFFERENTIAL IMPACTS OF ALTERNATE AUTOTROPH ASSEMBLAGES ON CARBON CYCLING**

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The intertidal zone in the northeast Pacific Ocean, through wave-mediated disturbance, can be an autotrophic mosaic of two highly productive assemblages: surfgrass (*Phyllospadix scouleri*) and macroalgae. Surfgrass meadows tend to dominate the intertidal zone through clonal expansion but wave-induced disturbance allows macroalgae to recruit. The transition between assemblages has been well documented, however, the effects of this transition on ecosystem function has been understudied. When we simulated wave-induced disturbance by experimentally removing patches of surfgrass and monitoring the site for species recruitment, a macroalgal community with increased diversity and biomass resulted the following year. Compared with surfgrass controls, the net primary productivity was also higher in macroalgal assemblages. Macroalgal forests had an
increased nitrogen content and released more dissolved organic carbon during photosynthesis, perhaps better provisioning other trophic levels in the near-shore ecosystem. PAM fluorometry indicated that surfgrasses have a competitive advantage over other macrophytes at low-light levels, though decreased photosynthetic activity at high light. Thus, contrary to other phototroph systems, disturbance in this system results in a phototroph community where carbon sequestration is increased. Finally, genomic analysis suggest that members of both assemblages have microbial partnerships for nitrogen fixation that may facilitate the high productivity we report.

Session 40: Physiological Ecology 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

DIFFERENT DRIVERS, COMMON MECHANISM; THE DISTRIBUTION OF A REEF FISH IS RESTRICTED BY OXYGEN AND TEMPERATURE LIMITS ON METABOLISM (YOUTUBE)
Duncan M.I.1*; James N.C. 2; Potts W.M. 3; Bates A.E. 4

1- Stanford University 2- South African Institute for Aquatic Biodiversity 3- Rhodes University, South Africa 4- Memorial University, Canada

The distributions of ectothermic marine organisms are limited to temperature ranges and oxygen conditions which support aerobic respiration, quantified within the Metabolic Index (MI) as the ratio of oxygen supply to oxygen demand. However, the utility of MI at local scales and across heterogeneous environments is unknown, yet these scales are often where actionable management decisions are made. Here we test if MI can delimit the entire distribution of marine organisms when calibrated across an appropriate temperature range and at local scales (10 km) using the endemic reef fish, Chrysoblephus laticeps, which is found in the highly heterogeneous temperature and oxygen environment along the South African coastal zone. In laboratory experiments we find a bi-directional (at 12 C) hypoxia tolerance response across the temperature range tested (8 to 24 C), permitting a piecewise calibration of MI. We then project this calibrated MI model through temperature and oxygen data to quantify various magnitudes of MI across space and time paired with complementary occurrence points. Overall, we find that C. laticeps’ distribution is limited by increasing temperatures towards its warm edge but by low oxygen availability towards its cool edge, which is captured within MI at fine scales and across heterogeneous oxygen and temperature combinations. Our results support the application of MI for generating local- and regional-scale predictions of climate change effects on organisms that can inform local conservation management decisions.

THERMAL TOLERANCE AND HEAT HARDENING ABILITY BETWEEN SEXES IN GAMBUSIA AFFINIS (YOUTUBE)
† Flores, J A M.*; Nelson, F. A.; Todgham, A. E.

Co-Author

As consequence of climate change, water temperatures may be increasing at rates that many fish are incapable of accommodating. Mosquitofish (Gambusia affinis), an invasive live-bearing fish commonly used to control mosquito populations, can tolerate extreme conditions including high water temperatures and acute temperature spikes and, hence, can wreak havoc in freshwater ecosystems by outcompeting their native counterparts. Given their capacity to tolerate rapid warming, mosquitofish invasiveness could continue to exacerbate. Several studies have conducted stress tolerance tests on mosquitofish to quantify to predict fitness consequences in a rapidly warming world. Few studies, however, have examined differences in stress tolerance between sexes, possibly overlooking an important factor in the fitness and ecological impact of each sex. This
study investigated differences in upper temperature tolerance (UTT) of mosquitofish sexes. I hypothesize females will have higher UTT and expanded capacity to increase thermal tolerance [i.e. heat hardening (HH)] compared to males. To test this, I assessed UTT using the critical thermal maxima methodology (CTMax) on males and females. Fish were given a 24-h recovery period before a second CTMax to evaluate heat hardening. Although nonsignificant, females had slightly higher capacities to heat harden. Ecological implications in a warming world will be discussed.

DIFFERENTIAL EXPRESSION OF HEATSHOCK PROTEIN 90 DURING THE MATERNAL-TO-ZYGOTIC TRANSITION IN STRONGYLOCENTROTUS PURPURATUS (YOUTUBE)
† Gill, J.R.; Spade, Z.C.; Zippay, M.L.

Sonoma State University

As ocean temperatures continue to rise due to climate change, it is important to understand how early embryonic stages of developing meroplankton are impacted. This research investigates the effects of temperature on the expression of the ubiquitous heat-shock protein 90 (hsp90) in purple sea urchin (Strongylocentrotus purpuratus) embryos during the maternal-to-zygotic shift (MZT), a critical stage of embryogenesis when maternal mRNAs and proteins are eliminated and zygotic transcription begins. Hsp90 has a vast suite of client proteins, some of which are directly involved in embryonic development, and perturbations to hsp90 abundance during the MZT results in drastic phenotypic variation. We will measure gene expression and protein abundance of hsp90 to determine the ability of purple sea urchin embryos to produce hsp90 through the MZT while undergoing heat stress. Preliminary data on red sea urchin embryos (S. franciscanus) suggest hsp90 expression does not show the same induction pattern compared to hsp70, another highly conserved heat-shock protein, thus we are interested if S. purpuratus embryos will show the same pattern. It is hypothesized that, even when thermally stressed, hsp90 expression will remain low during embryonic development due to the limited transcriptional capacity of the developing embryo making hsp90 a capacitor for phenotypic plasticity. Sea urchins are bioindicators of kelp forest ecosystems, thus furthering our knowledge of how embryos utilize plasticity may offer insight into how animals cope with warming ocean conditions.

THERMAL TOLERANCE OF BULL KELP (NEREOCYSTIS LEUTKEANA): IS ONE POPULATION MORE SENSITIVE THAN ANOTHER?
† Hotz, S.J.; Zippay, M.L.; Hughes, B.B.

Sonoma State University

Between 2013 and 2016, Sonoma and Mendocino County’s coastal environment experienced a series of dramatic environmental changes: sea star wasting disease, a series of marine heatwaves creating a warm water “blob”, and a boom in purple sea urchin populations. As a direct result, these counties experienced a 90% loss in its bull kelp (Nereocystis leutkeana) coverage. The main reason for this loss is the increase in sea urchin herbivory, but there was also the concern of the effect of ocean warming caused by “blob”. Bull kelp successfully grows in water ranging from 0 to 16 °C, and the “blob” has increased water temperatures to at least 17 °C. To our knowledge no study has investigated the cellular effects of temperature on bull kelp. We are interested in examining heat shock response, by specifically measuring the change in gene expression and protein abundance of the heat shock protein 70 (Hsp70) in response to temperature. We will compare the heat shock responses from wild collected kelp sporophytes and lab raised gametophytes from northern and southern sites. It is possible both hsp70 gene expression and Hsp70 protein abundance will increase at cooler temperatures for northern populations, while southern populations will exhibit these changes at higher temperatures. This study is significant because it will give us a better
understanding of the effects of temperature on bull kelp. The better we understand these effects, the more successful we may be in constructing management plans for bull kelp conservation in the face of continuing climate change.

**INTERTIDAL MUSSEL FREEZE TOLERANCE PLASTICITY (YOUTUBE)**
† Kennedy, J.R.; Harley, C.D.G; Marshall, K.E.

*University of British Columbia*

The intertidal mussel *Mytilus trossulus* can survive freezing. Freezing is an extreme stress to living cells, and so freeze tolerant animals accumulate protective molecules (termed cryoprotectants) to prevent the cellular damage caused by freezing. While much is known about the biochemical correlates of freeze tolerance in insects and vertebrates, the cryoprotectants that are used by intertidal invertebrates are not well characterized. Thus, we examined which cryoprotectants correlate with plasticity in freeze tolerance in mussels using metabolomics. We found that osmolyte accumulation was correlated with increased freeze tolerance, suggesting that osmolytes may be cryoprotective. We also investigated how plastic mussel freeze tolerance is and we found that *M. trossulus* freeze tolerance varies on a seasonal basis, along an intertidal shore level gradient, and with changing salinity. Acclimation to increased salinity (30 ppt) increased freeze tolerance, and mussels were more freeze tolerant during the winter. Mussel freeze tolerance also increased with increasing shore level. Osmolyte accumulation peaked in high salinity acclimated mussels and in the winter, but the concentration of most low-molecular weight metabolites did not vary with shore level, indicating that another mechanism is likely responsible for this driver of variation in freeze tolerance. By identifying osmolytes as a group of molecules that assist in freezing tolerance, we have expanded the biochemical repertoire of the mechanisms of freeze tolerance.

**CATEGORIZING THE SKIN MICROBIOME OF FOUR CALIFORNIA RAYS (YOUTUBE)**
† Kerr, E.N.1; Hesse, R. 1; Goodman, A.Z. 1; Lima, L.F.O. 1; Haggerty, M. 2; Mora, M.F. 1; Johnson, C.J. 1; Dinsdale, E.A. 3

1- San Diego State University 2- California Department of Fish and Wildlife 3- Flinders University

Microbes are some of the smallest and most important organisms on the planet. They contribute to biogeochemical cycling on a global scale, but also form close relationships with host organisms. Host microbiomes consist of bacteria, archaea, fungi, and other microscopic eukaryotes. Rays like all other macroscopic organism, are hosts to a microbiome. Rays are part of the class Chondrichthyes and have several features that may affect the structure of the skin microbiome, including mucus production, denticle structure, and benthic lifestyles. California is home to many species of rays including round rays, *Urobatis halleri*, bat rays, *Myliobatis californica*, butterfly rays, *Gymnura marmorata*, and thornback rays, *Platyrhoidis triseriat*. Here we describe the skin microbiome composition of *U. halleri*, *M. californica*, *G. marmorata*, and *P. triseriat*. Microbiome samples were collected in collaboration with California Department of Fish and Wildlife. Samples were sequenced using shotgun metagenomics and annotated using MG-RAST to identify the taxa and metabolic potential present in each microbiome. Preliminary analysis showed the microbiome of each species of ray demonstrated different metabolic potentials.

**PHYSIOLOGICAL RESPONSES OF TROPICAL DAMSELFISHES TO SEASONAL UPWELLING**
† Knight, N.S.1; Sellers, A.J. 1; Leray, M. 2; Guichard, F. 3; Torchin, M. 2; Altieri, A.H. 4

1- McGill University, Smithsonian Tropical Research Institute 2- Smithsonian Tropical Research Institute 3- McGill University 4- Smithsonian Tropical Research Institute, University of Florida
The effects of seasonal upwelling on tropical organisms are poorly understood. We expect that declines in temperature and changes in resource availability associated with upwelling will elicit physiological responses in feeding and digestion by reef fishes, and that these responses may differ across trophic groups. In particular, the temperature constraint hypothesis (TCH) predicts that low temperatures will especially disadvantage herbivorous fishes due to an impaired ability to digest plant material. We tested this hypothesis by comparing the feeding behaviour and digestive physiology of herbivorous, omnivorous, and carnivorous damselfishes on the Pacific coast of Panama during the warm non-upwelling season and cold upwelling season. If the TCH is correct, we predicted that during the upwelling season a) omnivores will consume more animal prey and less plant material, b) herbivores will invest more in their digestive organs, c) herbivores will exhibit reduced body condition, and/or d) herbivores will exhibit disturbed gut microbiomes. Our results show that all fishes respond similarly to upwelling: omnivores do not increase uptake of animal prey, and all species develop longer digestive tracts, but improved body conditions suggest this is a response to increased resource availability. Further, fishes’ gut microbiota show no signs of nutritional stress during upwelling. Altogether, our results demonstrate that seasonal upwelling benefits damselfishes regardless of trophic group and is not associated with decreased digestive performance among herbivores.

EFFECT OF HEAT STRESS ON METABOLIC RATE OF THE INVASIVE MUSSEL, MYTILUS GALLOPROVINCIALIS, ACROSS THE SPECIES’ RANGE (YOUTUBE)
Vasquez, M. C.*; Paniagua, M.
Loyola Marymount University

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

Mytilus galloprovincialis is an invasive mussel species with a range spanning the California Pacific coast. M. galloprovincialis is generally thought to be a heat tolerant species, but we do not fully understand the impact heat stress may have on mussel physiology. Thus, the purpose of our study was to examine the effect of location (Southern populations versus Northern populations) on metabolic rate in M. galloprovincialis. Mussels (n=24-32 per location) were collected from two Southern California populations (Marina Del Rey and Long Beach) and two Northern California populations (Bodega Bay and Sausalito) and acclimated in tanks for four weeks to control conditions (34 ppt, 18°C seawater). After the acclimation period, the mussels were placed in respirometry chambers to measure levels of oxygen consumption under different heat treatments (17°C, control and 23°C, acute heat stress), and then metabolic rate was calculated (MO2 as ml O2/min/g wet weight). Mussels from Bodega Bay and Sausalito showed lower metabolic rates overall (regardless of heat stress) compared to Long Beach and Marina Del Rey indicating an effect of site on metabolic rate (Two-Way ANOVA, p <0.05). However, there was no significant effect of acute heat stress on metabolic rate, suggesting that mussels from warmer climates have a higher metabolic rate overall and may be more vulnerable to changes to changes in ocean temperature due to climate change.

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SEASONAL HYDROMEDUSAN FEEDING PATTERNS IN AN EASTERN BOUNDARY CURRENT SHOW CONSISTENT PREDATION ON PRIMARY CONSUMERS (YOUTUBE)
Corrales-Ugalde, M.*; Sutherland, K.R.
University of Oregon
Dietary niche overlap between sympatric hydromedusan jellyfish could impose an enhanced predation and competition pressure on other planktonic organisms such as invertebrate larvae and fish. The Northern California Current (NCC) is a productive upwelling system, but the impact of hydromedusan feeding on the NCC food web has not been studied until now. During winter and summer of 2018-2019, we collected mesozooplankton from five stations along two cross-shelf transects in the NCC: the Newport Hydrographic line, OR and the Trinidad Head line, CA. We analyzed the gut contents of 11 hydromedusan species and the available prey community to 1) determine prey resource use by hydromedusae in the NCC and 2) determine temporal shifts in the trophic niches of the hydromedusan community, focusing on the prey selection patterns of the two most collected hydromedusae (Clytia gregaria and Eutonina indicans). Hydromedusae in the NCC fed mostly on copepods, appendicularians, and invertebrate larvae. Non-metric multidimensional scaling of hydromedusian diets showed seasonal consistency in prey resource use except for C. gregaria, which fed mostly on copepod eggs during winter and fed mostly on appendicularians and copepods during summer. Prey selectivity (Pearre’s C) for copepod eggs also increased during winter for C. gregaria and E. indicans. These results suggest a high degree of trophic overlap between hydromedusae in the NCC. Enhanced predation on specific prey can occur in short time intervals by hydromedusae like C. gregaria, which has feeding mechanics that allows it to consume differ

CONDITION-DEPENDENT EFFECTS OF MULTIPLE STRESSORS ON SEA URCHIN GRAZING

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Humboldt State University

As climate change increases, understanding how its multiple associated stressors will affect species and ecosystems is critical. To date, few studies have considered the ecological context (e.g., habitat type or condition) of organisms being impacted by such stressors. In California, a recent increase in purple sea urchin abundance and decline in bull kelp forests have increased urchin barren habitat, and led to differences in the condition of urchins, with healthy urchins inhabiting kelp forests and unhealthy urchins in barrens. To test whether these ecological contexts will influence the effect of multiple climate-related stressors on urchin grazing and survival, we did a 4-wk lab study that exposed kelp forest and urchin barren urchins to increasing magnitudes and durations of temperature, acidity, and hypoxia as predicted for future upwelling-driven ocean acidification. We found that grazing and survival of kelp forest urchins were resilient to stressors associated with current and near-future upwelling events, but were negatively affected by distant-future and extreme upwelling conditions. In contrast, grazing and survival of urchin barren urchins were highly sensitive to stressors associated with both current-day and future-predicted upwelling, as well as to increases in the magnitudes of acidity, hypoxia, and temperature across both upwelling and non-upwelling events in the future. These results indicate that urchin condition may play a role in mediating the effects of climate stressors on the urchin-bull kelp interaction.

TEMPORAL VARIATION IN EELGRASS WASTING DISEASE SEVERITY ALTERS PREFERRED FOOD AVAILABILITY FOR HERBIVORES

† Murray, N. A.*; DuBois, K; Stachowicz, J.J.

University of California, Davis

Eelgrass wasting disease has been responsible for multiple large die-offs of eelgrass (Zostera marina) over the last century, compromising critical habitat for fishes and invertebrates. Aside from these major outbreaks, little is known about the ecology of the disease, particularly regarding sub-
lethal biotic interactions between the pathogen, seagrass, and epifaunal species. In this study, I measured the severity of wasting disease in Bodega Harbor and investigated whether disease alters plant susceptibility to herbivory. I found that disease severity varies seasonally; the necrotic lesions caused by eelgrass wasting disease were virtually absent in early summer but peaked at nearly 20% leaf cover by midsummer. This large fluctuation in the amount of decaying plant tissue may change food availability for herbivores of eelgrass. To determine if herbivores showed a preference for lesioned or green plant tissue, I conducted a series of feeding trials offering isopod Pentidotea resecata a choice between the two tissue types. Lesioned tissue was strongly preferred. Consistent with this preference, lesioned tissue required 45% less force to penetrate than green tissue, whereas plant nutritional quality (C:N ratio) and concentration of potential chemical defenses (phenolic acids) did not differ between the tissue types. Facilitation of herbivore feeding by disease could influence seasonal progression in disease severity, so understanding feedbacks between disease extent and herbivory may enhance our ability to predict the trajectory of eelgrass wasting disease outbreaks.

**DRILLING DEEPER TO EXPLORE GEOGRAPHIC VARIATION IN PREY SELECTION (YOUTUBE)**

† Quan, J.R.∗; Longman, E.K.; Sanford, E.

*Bodega Marine Laboratory, University of California, Davis*

Optimal foraging and prey selection are generally regarded as plastic behaviors, whereas the role that spatial variation in selection might play in shaping geographic differences among predator populations is seldom considered. The predatory dogwhelk Nucella canaliculata and its main prey mussel Mytilus californianus are broadly distributed along the West Coast. Prior studies have documented genetic differences in drilling capabilities among populations of N. canaliculata, with snails from Oregon (OR) demonstrating much weaker abilities to drill thick mussels relative to snails from California (CA). However, whether these differences in drilling ability have also led to intrinsic variation among populations in predatory behavior is still unknown. To investigate this, we hatched and raised snails from six populations under common garden conditions for one year before exposing naïve snails to M. californianus of varying sizes to determine if populations have evolved differences in prey selection. We found that naïve snails from CA populations selected a broad range of prey sizes, including very large mussels, whereas snails from OR selected small mussels. This difference may arise from natural selection for behaviors that protect weaker drillers from wasting energy by choosing prey that are too large for them to drill successfully. Overall, our findings support the hypothesis that morphological variation in predator traits can be accompanied by associated selection on foraging behavior.

**RELATING ECOLOGICAL THEORY AND TETHERING DESIGN TO INFORM EXPERIMENTAL INERENCE ABOUT THE PREDATION PROCESS**

Rhoades, O.K.∗; Patrick, C.J. 2; Ogburn, M.B. 3; Ruiz, M.J. 3; Duffy, J.E. 3

1- Florida International University 2- Virginia Institute of Marine Science 3- Smithsonian Environmental Research Center

Predation is a key process that structures ecosystems, which is often difficult to observe and measure in nature without the assistance of manipulative experiments. Tethering experiments are broadly used to measure relative predation rates and prey mortality across situations by deploying and measuring loss or consumption of restrained prey in the field. However, tethering experiments have many artifacts and interactions between artifacts and treatments, which affect the inferences we can make about the predation process across situations in that system. Based on first principles of ecological theory, we develop a conceptual model that defines the four key elements of the
predator-prey interaction/process and the factors related to prey, predators, and the environment that influence these elements. Using a table of inference, we show how to measure various elements of the predation process using different common tethering designs. We then present four case studies of tethering experiments in marine ecosystems, and refer to the conceptual diagram and table to discuss how these designs can be used to make specific inferences about the predation process. Key insights include the importance of focusing inferences on predators (predation rates) versus on prey (prey mortality), the limitations of manipulating tethered prey characteristics to make indirect inferences about predator characteristics, and the necessity of using direct observations of predator-prey interactions to make inferences about all four elements of the predation process.

**ASSESSING THE ROLE OF SYMBIONT COMMUNITY ON CORAL PERFORMANCE UNDER LONG-TERM EXPOSURE TO WARMING AND ACIDIFICATION (YOUTUBE)**
† Souza, M.R*; Jury, C.P.; Toonen, R.

*Hawai’i Institute of Marine Biology*

Coral reefs are threatened by climate change driven ocean acidification (OA) and warming, which can lead to reduced coral growth, increased coral bleaching or mortality. One potentially important mechanism of long-term acclimatization to thermal stress is the change in community composition of the coral dinoflagellate endosymbionts (Family: Symbiodiniaceae). Symbiont shuffling can confer thermostolerance to the coral holobiont, however, coral endosymbiont community effects in response to OA are less clear. Here we report results from a multiyear mesocosm experiment to investigate the role of Symbiodiniaceae on holobiont performance in response to predicted future ocean conditions. We exposed replicated fragments of the eight most dominant Hawaiian coral species to predicted end of century temperature and OA conditions. Corals were collected from six locations around O'ahu, Hawai'i, including sites with different levels of environmental variation and differing coral community composition, and replicate fragments from each colony were maintained in a factorial design of temperature and pH for ~2.5 years. Symbiodiniaceae ITS2 amplicon sequencing and qPCR provided an in-depth identification of the symbiont types and the community changes across the experiment. Results showed that species richness of Symbiodiniaceae increased under warming, though community structure was not affected by any of the treatments. This study provides insight about the role of environmental history and symbiont shuffling in determining the survival of corals under future climate conditions and can help understand the role of symbiotic community in coral resilience.

**Macroalgal associational refuge from corallivory depends on coral colony size (YOUTUBE)**
Srednick, G.S.*

*California State University, Northridge*

Coral reef communities are increasingly threatened by shifts in dominance from coral to macroalgal dominated states. Macroalgae can outcompete corals through physical and chemical effects, and can subsequently alter reef dynamics in some coral reef systems. However, some macroalgae might provide size-dependent associational refuge from corallivory for scleractinian corals. In this study, we test the effect of a competitive macroalga, *Turbinaria ornata*, on mediating corallivory on massive *Porites spp.* of different sizes to assess its value as refuge for corals. Over a period of 26-d, corallivory was examined among colonies of *Porites spp.* across a size range that were deployed in-situ in three experimental treatments: (1) fully exposed to corallivory, (2) exposed to corallivory within perimeter of *T. ornata*, and (3) fully protected from corallivory by cage enclosure. The amount of tissue damage by corallivory was 3.7 times lower in the presence of *T. ornata* when compared to the fully exposed colonies. Corallivory was disproportionately higher on fully exposed colonies.
small vs. large colonies, but was mediated by the presence of *T. ornata* near smaller colonies, whereas larger colonies did not benefit from the same refuge. While there are demonstrated negative competitive effects of macroalgae on scleractinian corals, these results suggest the potential value of context-dependent benefits from some macroalgae.

**CRAB IMPACTS ON CORDGRASS DEPEND UPON CRAB COMMUNITIES AND EDAPHIC CONDITIONS** (YOUTUBE)
Walker, J.B.*; Grosholz, E.D. 2; Long, J.D. 3

1- Southern California Coastal Water Research Project 2- University of California, Davis 3- San Diego State University

Environmental factors can shift the effect of burrowing animals on plants. Unfortunately, we lack an ability to predict when, where, and how burrowers will influence vegetation because few studies have used comparative-experimental approaches across multiple sites and years. We combined field, laboratory, and statistical modeling to predict burrowing crab effects in salt marshes. At three sites in both northern and southern California, we conducted multi-year crab manipulations and measured the responses of the two dominant plants: Pacific cordgrass and perennial pickleweed. Then, we used statistical models to predict crab effects from factors related to the crab community and soil conditions. Crab effects varied from strongly positive to strongly negative, and depended upon our estimate of the total consumption pressure exerted by crabs and sediment conditions. Crabs facilitated cordgrass at low total consumption pressure, extreme salinities, and intermediate levels of ammonium. Our results suggest that it will be challenging to predict how these crab-plant interactions will change under future climate scenarios. For example, warmer temperatures should lead to more negative impacts of crabs on cordgrass, but saltier soils could weaken positive effects of crabs at low salinity marshes but enhance crab effects at intermediate salinity marshes. Understanding the environmental controls on these interactions will help promote cordgrass productivity and stabilize salt marsh ecosystems.

Session 42: Ecosystem Assessment 2
* indicates presenting author, † indicates eligibility for Best Student Paper Award

**Advancing the use of drones and remote sensing approaches in ecological studies of coastal ecosystems.** (YOUTUBE)
Garza, C.D.*

*California State University, Monterey Bay*

Coastal habitats are some of the most heavily monitored ecosystems in the world owing to their economic and ecological importance. Traditional monitoring methods, such as quadrats and meter tapes, have provided valuable data on trends and status on coastal resources. However, these approaches have limitations centered about the spatial and temporal scales across which they can be used. With ongoing climatic shifts, new approaches are needed to assess how climate change is affecting coastal habitats across multiple scales of organization. In this talk, I discuss an aerial drone program created as part of NOAA’s Center for Coastal and Marine Ecosystems (CCME) to support next generation monitoring tools for assessing status and trends in coastal ecosystems. Aerial drones have seen increased use in coastal studies due to their ability to capture multi-scale data on the distribution and abundance of coastal resources at a relatively low cost. Drones, outfitted with high-resolution digital cameras, provide a method for capturing multi-scale data on coastal habitat distribution and community composition at scales of a few centimeters up to hundreds of meters. Drone data can provide stakeholders, resource managers and researchers with timely information
on changes in coastal habitat across California and support the emerging needs of 21st century marine science.

**LOCAL VS. SITE-LEVEL EFFECTS OF ALGAE ON CORAL MICROBIAL COMMUNITIES** *(YOUTUBE)*
† Briggs, A.A.; Brown, A.L. 2; Osenberg, C.W. 1

1- Odum School of Ecology, University of Georgia 2- Woods Hole Oceanographic Institution

Microbes influence many ecosystem processes, including the dynamics and health of macroorganisms and their interactions with other species. In coral reefs, microbes mediate some of the negative effects of algae on corals, which have been investigated at local scales, e.g., when corals are in contact with algae. However, it is unknown whether these effects extend to larger spatial scales, such as at sites with a high abundance of algae. We investigated how algal contact and site-level algae influenced coral microbial communities in a field study at two islands in French Polynesia, Moorea and Mangareva, at sites that fell along a gradient of macroalgal cover. At each site we sampled prokaryotic microbial communities associated with different reef substrates, including corals, macroalgae, turf algae, and water (sampling consistent species at each island), with coral samples taken from individuals that were touching turf, macroalgae, and not touching algae. We found that the composition of microbial communities of all substrate types varied with site-level macroalgal cover, and coral communities became more similar to algal communities at sites with high macroalgal cover and with local algal contact. However, site-level and local algae had antagonistic effects on coral microbiome alpha and beta diversity. Our results indicate that corals are affected by algae outside of their immediate vicinity, and local- and site-level algae can obscure each other's effects when both scales are not considered.

**INTERACTIONS BETWEEN TIDAL CURRENT SPEED AND DEPTH INFLUENCE NEARSHORE BENTHIC FISH COMMUNITIES IN THE SALISH SEA** *(YOUTUBE)*
† Campbell, J.A.*; Juanes, F; Dudas, S

*University of Victoria*

The interaction between tidal current speed and depth appears to be a strong driver of fish communities in the Southern Gulf Islands of BC. This interaction can act as an abiotic surrogate for fish biodiversity. High and low current sites were surveyed at two depths (3 and 15 meters below chart datum) by SCUBA divers from October 2019 to March 2020 in the Southern Gulf Islands of BC Canada. Fish community compositions were quantified based on fish species richness, abundance, and biomass. Water current, temperature, salinity, and primary and secondary substrate type data were also collected to investigate relationships between these metrics and the fish community compositions. Results from these analyses indicate that fish species richness and abundance differ significantly between survey depths but not by current regime. However, fish community composition analyses indicate that while the 3-meter depth fish communities are nearly identical, the communities are unique between high and low current sites at 15-meter depths. This difference was largely driven by abundance and length differences of *Artedius harringtoni* and *Rhinogobiops nicolsii*, abundance differences of *Jordania zonope*, and length differences of *Hexagrammos decagrammus* males. Increased fish species richness and abundance at high current sites at depth should be considered for any potential marine spatial planning, fish conservation efforts, or tidal power turbine placement.

**LONG-TERM NO-TAKE PROTECTION INCREASES THE STABILITY OF KELP FOREST ECOSYSTEMS** *(YOUTUBE)*
† Peleg, O.*; Blain, C.O.; Shears, N.T.
Shallow temperate reefs are typically dominated by macroalgal forests, but overfishing may shift these highly productive ecosystems to denuded urchin barrens. No-take marine reserves can restore predatory interactions that generate cascading effects that reverse the shift to urchin barrens. However, the long-term effects of protection on kelp (*Ecklonia radiata*) forest ecosystem stability and the role of reserves in reversing or preventing shifts to algal turf has not been examined. Using 20 years of monitoring data from New Zealand’s oldest marine reserve (Leigh; est. 1977), we explored temporal variation in ecosystem state under no-take protection, and compared this to nearby fished reefs. Fished habitats fluctuated between urchin barren, algal turf and occasionally algal forest states, while reserve sites were dominated by algal forests with a clear trajectory towards monospecific kelp forests. Protection increased the resilience and resistance of kelp forests through a net positive effect on macroalgae, and a net negative effect on sea urchins and turfs. Stability was higher in the reserve, where fewer shifts occurred and ecosystem variation was smaller, compared to fished reefs. We conclude that long-term no-take protection is effective in promoting stable kelp forest ecosystems.

**3D MODELS OF MARITIME HERITAGE SITES CREATED FROM ROV VIDEO TO MONITOR ECOCYLOGY OF ARTIFICIAL SUBSTRATE**

† Seida, M.S.1; Solymar, R. 2; Moore, S. 3

1- *California State University, Monterey Bay Undergraduate* 2- *California State University, Monterey Bay* 3- *California State University, Monterey Bay, Ecosystem Electronics Lab*

What species of sessile invertebrates initially colonize new shipwrecks? Are they different from those that colonize nearby natural reefs? Does algal diversity and succession differ depending on substrate type? How do the resulting benthic communities impact the longevity of these maritime heritage sites? For the effective management of Monterey Bay National Marine Sanctuary’s (MBNMS) 463 known maritime heritage sites, it is critical to have comprehensive documentation of the sites and the benthic ecology they provide habitat for, both on spatial and temporal scales. However, many maritime sites are below safely accessible scuba depths. Recent master’s project work by Ryan Solmar at CSUMB has demonstrated that 3D photogrammetry models generated from video captured by a small Remotely Operated Vehicle (ROV) contain sufficient detail to allow identification, quantification, and precise localization of sessile macroinvertebrates on submerged wrecks. One challenge with applying this technique in deeper, darker water is that video lights on small ROVs often generate enough backscatter to interfere with the photogrammetry algorithms. Here I present the preliminary findings of a brief engineering study to determine optimal light placement on a BlueROV2 (BlueRobotics.com) for documenting sessile macroinvertebrate communities in 3D photogrammetry models of deep wrecks. The system measured the position of the lights relative to a fixed GoPro camera to best minimize backscatter while maximizing illumination to facilitate clear video footage in a variety of marine piloting conditions.

**FUTURE TEMPERATURE AND SALINITY IN PUGET SOUND, WASHINGTON STATE UNDER CMIP6 CLIMATE CHANGE SCENARIOS**

† Walker, S.L.1; Morzaria Luna, H.N. 2; Kaplan, I. 3; Harvey, C. 3; Petatán-Ramírez, D. 4

1- *Boston College, NOAA Ernest F. Hollings Scholarship Program* 2- *Long Live the Kings* 3- *Northwest Fisheries Science Center, Conservation Biology Division* 4- *Universidad Autónoma de Baja California Sur*
In Washington State, climate change will reshape the Puget Sound marine ecosystem through bottom-up and top-down processes, directly affecting species at all trophic levels. We applied analytical approaches to better understand future climate change effects on Puget Sound oceanography. We used empirical downscaling techniques to derive high resolution time series of future sea surface temperature and salinity, based on scenario outputs of two General Circulation Models, GFDL-CM4 and CNRM-CM6-1-HR, which were created as part of the CMIP6 - Coupled Model Intercomparison Project Phase 6. We applied a delta-downscaling approach to a Regional Ocean Modeling System time series, yielding short (2020–2050) and long-term (2070–2100) forecasts. Downscaled output for Puget Sound showed variability between scenarios and models, but overall there was strong model agreement forecasting an increase in temperature and a decrease in salinity. Spatially, we found regional differences for both variables. This study is a first step to translating CMIP6 outputs to higher resolution predictions of future conditions in Puget Sound. The climate projections for Puget Sound oceanography will be used to drive the Atlantis ecosystem model for Puget Sound, an end-to-end ecosystem modeling approach that represents all trophic levels and evaluates the species-level impacts of climate change. This project is part of a Washington State Sea Grant funded project, “Evaluating the effects of Southern Resident orcas recovery actions and external threats in the marine ecosystem of Puget Sound.”

**Investigating the effectiveness of aerial monitoring of spatial and temporal changes of Santa Catalina Island rhodolith beds** ([YOUTUBE](https://www.youtube.com/watch?v=example))

Wickliff, C.L. 1*; Haupt, A.J. 2; Garza, C. 2; Edwards, M.E 3; Steller, D.L. 4

1- Moss Landing Marine Laboratories, California State University, Monterey Bay 2- California State University, Monterey Bay 3- San Diego State University 4- Moss Landing Marine Laboratories

The distribution and abundance of rhodolith beds off Santa Catalina Island, California are impacted by natural and anthropogenic factors. These complex, unattached coralline habitats provide food and shelter for important species, like food for the spiny lobsters. However, little is known about temporal variation in bed cover and distribution. Abiotic factors like heavy storms and surge can change bed boundaries and shape. Anthropogenic factors, such as disturbance from mooring chains, can create patchiness within beds. Determining bed distribution and tracking changes in habitats have historically been done using labor-intensive SCUBA diving. This approach has limitations in the temporal and spatial extent across which it can be employed. Emerging technologies, such as drones, may be able to address these limitations and provide an ability to survey large areas of habitat beyond those which can be surveyed by SCUBA. Drones may also provide improved data resolution relative to satellite-based approaches to surveying coastal habitat. The objective of this research is to estimate how well drones can assess temporal and spatial shifts in rhodolith bed boundaries compared to SCUBA surveys. Initial results suggest drone imagery compared to subtidal surveys can detect shifts in rhodolith bed boundaries and the occurrence of anthropogenic (i.e. mooring scar) disturbances. Drones may provide a long-term solution to acquiring survey data across the temporal and spatial scales.

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

**HAS PISASTER OCHRACEUS RECOVERED ITS KEYSTONE PREDATOR ROLE IN CALIFORNIA AND OREGON?** ([YOUTUBE](https://www.youtube.com/watch?v=example))

Necarsulmer, A.M. 1*; Cortez, M.L. 1; Gravem, S.A. 2; Raimondi, P.T. 1; Menge, B.A. 2

1- University of California, Santa Cruz 2- Oregon State University
Starting in 2013, sea star wasting syndrome (SSWS) caused declines in ochre sea star (*Pisaster ochraceus*) densities along the West Coast of North America. The keystone predation hypothesis predicted their mussel prey *Mytilus californianus* would be freed from top-down control, allowing mussels to competitively dominate low intertidal space holders and decrease biodiversity.

We examined whether predation rates by *Pisaster* on *Mytilus* varied over time in response to SWSS and over space from Southern California to Oregon at 15 sites. At each site, we deployed 10 patches of 30-50 mussels, and either allowed or disallowed *Pisaster* predation using cages. We tracked mussels monthly between 2016 and 2019, and will compare our results to similar experiments done before SSWS. Preliminary findings suggest strong spatial and temporal variation in predation rates and degree of recovery of the keystone role of *Pisaster*. We will also investigate whether adult *Pisaster* density or biomass are better predictors of *Mytilus* predation rates. These findings will help us understand why some sites were apparently resilient to community change after the loss of their top predator, while other sites experienced rapid community shifts. Understanding how communities can maintain stability in the wake of trophic downgrades will help us understand how worldwide declines in top predators may affect ecosystems.

**UPPER LIMIT OF DISTRIBUTION OF THE LIMPET *PATELLA ULYSSIPONENSIS*: EFFECTS OF INTERSPECIFIC COMPETITION AND HUMIDITY ENHANCEMENT**

Ornelas, S.; Seabra, M. I.; Nobre, D.; Cruz, T.

*affiliation not listed*

*Patella ulyssiponensis* is abundant on the low-shore, while *Patella depressa* is abundant on the mid-shore open rock of SW Portugal. Two processes potentially affecting *P. ulyssiponensis* absence from mid-shore open-rock areas were analysed: i) interspecific competition with *P. depressa* and ii) humidity enhancement of the rocky substrata. A field experiment in which *P. ulyssiponensis* individuals were transplanted to mid-shore open-rock areas where the initial densities of the two limpet species were manipulated and/or local humidity conditions were enhanced was set up with appropriate controls in 2018. After nine months, a proxy of survival (the percentage of permanence inside experimental cages), the growth rate and the feeding intensity of *P. ulyssiponensis* were measured. Feeding intensity was estimated through the deployment/collection of wax discs and this has implied a description of the radular marks of these two congeneric patellids on wax discs for the first time. Our results supported the theory of interspecific competition as a process leading to the absence of *P. ulyssiponensis* on the mid-shore open-rock. There was no independent effect of humidity enhancement on any of the studied variables, but it was found that growth of *P. ulyssiponensis* in the presence of *P. depressa* was significantly higher in humidity-enhanced conditions, and that humidity enhancement might reduce competition between both species.

**THE DIVERSITY INITIATIVE FOR THE SOUTHERN CALIFORNIA OCEAN (DISCO) — PROGRAMS AND PROJECTS**

Pentcheff, N.D.; Harris, L.; Omura, K.; Wall, A.R.; Wall, J.; Wetzer, R.

*Natural History Museum of Los Angeles County*

The *Diversity Initiative for the Southern California Ocean* (DISCO) program at the Natural History Museum of L.A. County is pursuing a number of initiatives with a primary focus on coastal biodiversity. We are developing the use of environmental DNA (eDNA), most recently complementing conventional surveys of fish and invertebrate biodiversity in the Ports of Los Angeles and Long Beach. With UCLA and UC Santa Cruz, we participate in *Protecting Our River* ([https://www.protectingourriver.org](https://www.protectingourriver.org)), an innovative interweaving of eDNA and community
participation to enhance biodiversity monitoring in the L.A. River. Using vernal pools as our testbed, we are developing “no-take” eDNA monitoring of threatened and endangered species in the fragile vernal pool community. With collaborators state-wide, we participate in the California Conservation Genomics Project (https://sites.lifesci.ucla.edu/eeb-CCGP), applying whole-genome sequencing across a broader diversity of taxa than ever attempted before, a component of the Earth BioGenome Project (https://www.earthbiogenome.org/). DISCO forms the core of NHMLA’s recent NSF award as the lead institution (of 19 nationwide) to plan and manage digitization of the nation’s marine invertebrate collections, a program expected to last 4–5 years (https://tinyurl.com/diginadbc). Based at a public institution, we have the opportunity to promote awareness of biodiversity through intensive internships (this year completely remote experiences, yet still involving fieldwork) and STEM teacher training in collaboration with CSU Dominguez Hills.

Classification and Mapping of Marine Habitats Using Drone Data
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1- NOAA Center for Coastal Marine Ecosystems 2- California State University Monterey Bay

In this research study, data from drones has been collected from Santa Catalina Island in Los Angeles with the focus of seeing whether or not autonomous drones can be used to map and classify marine habitats. Since climate change is causing a rapid change in ecosystems, new survey methods are needed to capture how rapidly these systems are changing. Improved access to autonomous drones as a monitoring platform has allowed for the advanced technologies to be available such as thermal sensors and computer vision. With this new technology, we now have the ability to collect data with lower financial costs and risks while increasing productivity in data collection. The drones used in this study were used to monitor areas on the island that have historically been mapped using quadrat and meter tape approaches. The rocky intertidal habitats which happen in between low and high tides were monitored by drones in order to identify species and general habitat types such as algae zones and mussel beds. Climate change rising is causing a shift in marine habitats found in rocky intertidal, and using autonomous drones may give us an insight of whether or not this method of classification and mapping is useful when it comes to marine habitats. Our initial results suggest that drones provide a faster method for collecting marine habitat data without losing data resolution when compared to previous survey methods.

How the mighty have fallen: Indirect effects of sea star wasting syndrome on mussel abundance in the Northern Gulf of Alaska (YOUTUBE)
Traiger, S.B.1; Bodkin, J.L. 1; Coletti, H.A. 2; Ballachey, B. 1; Dean, T. 3; Esler, D. 1; Iken, K. 4; Konar, B. 4; Lindeberg, M.R. 5; Robinson, B. 1; Suryan, R.M. 5; Weitzman, B. 6

1- USGS Alaska Science Center 2- National Park Service 3- Coastal Resources Associates, Inc. 4- University of Alaska Fairbanks 5- NOAA Alaska Fisheries Science Center 6- NOAA Kasitsna Bay Laboratory

Sea stars are keystone predators in rocky intertidal habitats, affecting communities through predation on primary space holders such as mussels. Sea star wasting syndrome (SSWS) recently led to a decline in star abundance throughout the northern Gulf of Alaska. We investigated 1) how mussel abundance changed since onset of SSWS, and 2) which star species best explain variation in mussel abundance. Star abundance, mussel percent cover, density of large mussels, and density of mussels of all sizes from core samples were surveyed approximately annually at Katmai National Park (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ) and western Prince William Sound (WPWS). At KATM, KBAY, and KEFJ star abundance declined 40 – 100% after SSWS. Mussel cover increased above the long-term mean 1 – 3 years after declines in star abundance at
KATM, KBAY, and KEFJ, but not at WPWS. Large mussel abundance increased to 65% above the long-term mean at KATM after SSWS. Large mussel abundance increased slightly at KBAY but did not increase at KEFJ or WPWS. Mussel abundance from cores, which included recruits, did not differ before and after the onset of SSWS. *Pisaster ochraceus* and *Pycnopodia helianthoides* abundance together explained 23.6% of variation in the mussel metrics. The dramatic decline in these stars resulting from SSWS appears to have relaxed top-down pressure on the mussel population, allowing for increased abundance. In turn, increased mussel abundance may affect intertidal biodiversity and abundance or performance of nearshore vertebrates that consume mussels.

**PARENTAL EFFECTS ON LARVAL THERMAL TOLERANCE IN CALIFORNIA MUSSELS (MYTILUS CALIFORNIANUS)** (YOUTUBE)
† Heidi R. Waite’; Cascade J. B. Sorte

*University of California Irvine*

Under changing climate conditions, marine organisms will need to cope with or adapt to increasing temperatures to persist. Parental effects, where offspring responses to environmental change are influenced by parental environments through non-genetic changes and maternal provisioning, may influence the ability of populations to cope with thermal stress. This study evaluated whether thermal environments across a natural gradient (tide height) impacted the temperature tolerance of larvae of the mussel, *Mytilus californianus*. Adult mussels were collected from the rocky intertidal of Newport Beach, CA, USA. LT₅₀ (temperature lethal to 50% of individuals) was quantified for field-collected adults and their 3-day old veliger larvae raised in the laboratory. We used a generalized linear mixed model approach to examine which factors predicted larval mortality. The best-fit model indicated that LT₅₀ assay temperature, adult (parent) LT₅₀, and parental environment (collection tide height) all significantly contributed to level of larval mortality. Overall, survival was lowest for larvae with parents who were collected from the warmest environment (high tide height). These results suggest parental effects are maladaptive for thermal tolerance and indicate negative effects of stress. Stressed mussels may invest less in reproduction leading to lower larval tolerances. Thus, maladaptive parental effects could leave larvae more vulnerable to thermal stress and impact the survival of the mussel under climate change.

**CHEMICAL DEFENSE OF A COMMON, WIDESPREAD SEA SLUG GENUS MAY ALTER ESTUARINE FOOD WEBS BY DETERRING DIVERSE PREDATORS** (YOUTUBE)
† Weiss, P.K.; Krug, P.J.

*California State University, Los Angeles*

*Alderia* species are small sea slugs that reach exceptional densities (>1000/m²) on estuarine mudflats throughout the northern hemisphere, and could be an important food source to juvenile fish and waterfowl. Here, we show that this potential food reserve is rendered unpalatable by a potent chemical defense that deters ecologically relevant fish, crab and worm predators, diverting primary production away from higher trophic levels. In contrast to prior work, we found strong anti-predator effects against three appropriately sized and co-occurring predators tested: the arrow goby *Clevelandia ios*, polychaete worm *Nereis arenaceodentata*, and lined shore crab *Pachygrapsus crassipes*. Video-recorded feeding assays show live *A. willowi* and *A. modesta* were never consumed, whereas all acetone-extracted control slugs were eaten. Organic extracts of both *Alderia* species rendered food pellets completely deterrent to all predators. Live slugs and extract-treated pellets triggered a gagging reflex in all predators. The chemical defense of *Alderia* species may be a keystone molecule influencing energy flow through estuarine ecosystems due to the abundance of the slugs in sensitive nursery and nesting habitat for many consumer species.
EXPLORING THE EFFECTS OF THE COMMON ROCKWEED AND THE ATLANTIC OYSTER DRILL ON THE DISTRIBUTION AND RECRUITMENT OF OLYMPIA OYSTERS (YOUTUBE)

Wood, Acy E*; Blumenthal, Jeffrey G. 2; Knapp, Corryn 3; Chang, Andrew L. 3; Zabin, Chela J. 3

1- Smithsonian Environmental Research Center, Moss Landing Marine Laboratories 2- Smithsonian Environmental Research Center 3- Smithsonian Environmental Research Center, San Francisco State University

Olympia oysters, Ostrea lurida, once harvested from San Francisco Bay (SFB), have declined throughout the Pacific Coast from Baja California to British Columbia. Genetically distinct populations of O. lurida remain in SFB and conservation efforts to enhance population levels began in the 2000’s. Our research addresses three objectives to further O. lurida restoration: 1) examine whether an intertidal alga, Fucus distichus, facilitates O. lurida recruitment within SFB, 2) develop methods for transplanting F. distichus, and 3) examine whether introduced drills, Urosalpinx cinerea, limit O. lurida survival within SFB. To investigate the first two objectives, 3 rows of 10 settlement blocks were constructed at Giant Marsh, Richmond CA (GM). F. distichus individuals were transplanted to 5 experimental blocks in each row. Over the past year, GM was surveyed for O. lurida sizes and settling density, and F. distichus canopy density on experimental blocks. Preliminary results suggest Fucus distichus requires transplantation in dense quantities to observe possible effects. Our first and last objectives were originally designed to utilize volunteers surveying sites within SFB where O. lurida, F. distichus, and U. cinerea coexist. However, due to COVID-19, this objective was modified for safety concerns. Instead, a website for volunteer training was developed for future use. Additional F. distichus transplantation will be done at the end of 2020 in greater densities to refine transplantation methods and to better recreate natural F. distichus canopies.

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

DEVELOPMENTAL PLASTICITY OF PACIFIC HERRING UNDER COMBINED HEATWAVE AND HIGH PCO2 CONDITIONS (YOUTUBE)

Murray, C.S.*

University of Washington

Forage fish are foundational species in the Puget Sound ecosystem. Prominent taxa like the Pacific herring (Clupea pallasii) directly support populations of higher trophic organisms like marine mammals, seabirds, and commercially important fish. Forage fish also tend to respond strongly to environmental variability and therefore may be particularly sensitive to marine climate stressors like acidification and marine heatwaves. Controlled laboratory experiments are powerful tools to assess species vulnerability to near-future conditions. I reared wild Pacific herring embryos in a factorial experiment to test the individual and combined effects of a heatwave and end-of-century ocean acidification (2,500 μatm pCO2). Heatwave characteristics were informed by analyzing a long-term regional dataset (onset: 0.85°C/°d−1; peak intensity: +4.3°C). Heatwave exposure increased embryo metabolic rates by ~25%. There was a small but significant increase of Q10 values under high CO2. The heatwave reduced time-to-hatch by ~3 d while high CO2 increased hatching duration by 0.75 d. Embryo survival was unaffected by treatment conditions but the rate of developmental deformities doubled under the heatwave to ~7%. The heatwave reduced larval size at hatch by ~10% and also decreased remaining yolk reserves by 28%. Exposure to high CO2 had minimal effects on hatch size and endogenous energy supply. In summary, a moderate heatwave had
adverse effects on the development of herring with implications for larval recruitment while exposure to high CO₂ produced few measurable impacts.

**EXPERIMENTALLY DECOUPLING THE CARBONATE CHEMISTRY SYSTEM REVEALS MULTIPLE CONTROLS ON SHELL FORMATION IN MYTILUS CALIFORNIANUS** *(YOUTUBE)*
† Ninokawa, A.T.; Saley, A.M.; Shalchi, R.; Gaylord, B.P.

*Bodega Marine Laboratory*

Calcification, the formation of calcium carbonate shells or skeletons, is an important process for many marine organisms. This process can be particularly sensitive to perturbations in the carbonate chemistry system of seawater, though the exact nature and extent of this susceptibility remains incompletely understood and varies among species, and potentially among life stages within species. Furthermore, there are multiple correlated components of the carbonate system, making it difficult to distinguish between various proposed controls on calcification. Here, we report findings from experiments where we decoupled 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 calcification process, and, independently, pH as excess protons can inhibit the removal waste products from the site of calcification. Omega, the calcium carbonate saturation state, was a minor contributor to the overall calcification signal. This type of experimental approach can be applied across marine calcifiers to gain a better understanding of the mechanisms underlying shell formation and allow better predictions of how they will respond to future changes to ocean carbonate chemistry.

**THE MORPHOLOGY AND THERMAL FUNCTION OF SEA OTTER PELTS ACROSS ONTOGENY** *(YOUTUBE)*
† Riordan, K.C.; Thometz, N.M.; Batac, F.; Liwanag, H.E.M.

1- *California Polytechnic State University SLO* 2- *University of San Francisco* 3- *Office of Spill Prevention and Response, California Department of Fish and Wildlife*

Sea otters (*Enhydra lutris*) are unique among marine mammals in that they lack blubber and instead must rely on especially thick fur to keep warm in the marine environment. Despite a wealth of knowledge regarding the functional morphology of the adult pelage, almost nothing is known about the characteristics of lanugo (newborn pelage). To better understand the characteristics of sea otter fur across ontogeny, we investigated the morphology and thermal function of otter pelts (n=39) across six age classes: neonates, small pups, large pups, juveniles, subadults, adults. Guard hair length was collected for morphological analysis. Thermal conductivity and thermal resistance were measured to determine thermal function of pelts. Neonates and small pups had longer guard hairs compared to older age classes (p<0.001), consistent with the timing of the molt of the lanugo and growth of more adult-like pelage. The neonatal pelage had a higher thermal conductivity in air (p<0.001) compared to the juvenile, subadult, and adult pelage, suggesting lanugo pelts are poorer insulators. However, thermal resistance did not differ across age classes (p=0.612), as the greater thickness of the lanugo pelage compensated for the higher thermal conductivity. Future work will determine fur density using histological methods and measure thermal function of pelts in water. This study is the first to investigate the functional morphology of sea otter lanugo, and will connect the fur structure to its thermal function.
RESOURCE ALLOCATION TO A STRUCTURAL BIOMATERIAL: INDUCED PRODUCTION OF BYSSAL THREADS DECREASES GROWTH OF A MYTILID MUSSLE

Roberts, E.A. 1*; Newcomb, L.A. 2; McCartha, M.M. 3; Harrington, K.J. 3; LaFramboise, S.A. 3; Carrington, E. 2; Sebens, K.P. 4

1- Claremont McKenna College, Department of Biology and Friday Harbor Laboratories, University of Washington 2- Department of Biology and Friday Harbor Laboratories, University of Washington 3- Friday Harbor Laboratories, University of Washington 4- Department of Biology, School of Aquatic Fisheries Sciences, and Friday Harbor Laboratories at the University of Washington

Specialized mechanical structures produced by organisms provide crucial fitness advantages. The energetic cost associated with producing these structural materials and the resulting energetic trade-off with growth, however, is rarely quantified. We integrate resource allocation to structural material production with an energetic framework by combining an experimental manipulation with an energetic model. Mytilid bivalves produce byssus, a network of collagen-like threads that tethers individuals to hard substrate. We hypothesized that a manipulation that induces the production of more byssal threads would result in increased energetic cost and decreased growth. In month-long field experiments in spring and autumn, we severed byssal threads of Mytilus trossulus across a range of frequencies (never, weekly, daily), and measured shell and tissue growth. We then quantified the costs associated with the production of byssal threads using a Scope for Growth model. We found that byssal thread removal increased byssal thread production and decreased growth. The cost calculated per byssal thread was similar in the spring and autumn (~1 J/thread). The energetic cost of producing byssal threads was 2-8% percent of the energy budget in control groups that had low byssal thread production, and increased 6 to 11-fold (up to 47%) in mussels induced to produce threads daily. We propose that characterizing the trade-off between the cost of biomaterial production and growth has implications for understanding the role of trade-offs in adaptive evolution and improved conservation practices.

ELEVATED TEMPERATURE AFFECTS PHENOTYPIC PLASTICITY IN THE BULL KELP NEREOCYSTIS LUETKEANA

† Supratya, V.P.*; Coleman, L.J.M; Martone, P.T.

University of British Columbia

The sensitivity of kelps to elevated temperatures has been linked to recent declines in some kelp populations. However, it remains unclear how thermal stress affects the ability of kelps to respond to other environmental factors, which could influence their vulnerability to climate change. We investigated the effect of thermal stress on the ability of the bull kelp Nereocystis luetkeana to acclimate to its surrounding hydrodynamic environment through tension-regulated plasticity in blade morphology. We first determined optimal and stressful temperatures for N. luetkeana by measuring growth over nine temperatures from 5 to 22 °C. We then exposed N. luetkeana blades to factorial combinations of temperature (13°C and 20°C) and tension (0.5N and 2.0N) simulating different flow conditions, and measured changes in blade length and width after seven days. The temperature at which N. luetkeana exhibited maximum growth was estimated to be ~11.9°C, though growth was high over a relatively wide temperature range. Thermally stressed N. luetkeana maintained morphological responses to simulated high flow, but were inhibited from acclimating to low flow, indicated by an inability of blades to widen. Our results suggest that N. luetkeana in sheltered habitats may be particularly vulnerable to climate warming, where an inability to adjust blade morphology to local hydrodynamic conditions could drive declines at sublethal levels of warming.
SEA SLUGS SAFEGUARD SEAGRASSES: AN OVERVIEW OF THERMAL TOLERANCE IN EPIPHYTE GRAZERS (YOUTUBE)
Tanner, R.L.*

UC Davis

Seagrass ecosystems worldwide play important roles in providing essential habitat for fish and invertebrates, mitigating coastal erosion, and regulating local biogeochemical processes. Seagrasses are threatened under climate change with increased epiphytic growth, which potentially reduces blade photosynthesis and plant growth. Epiphyte grazers can play a significant role in reducing the stress of epiphytic growth on seagrasses, however; it is important to understand how their own physiology and behavior shifts under the effects of climate change. A key epiphyte grazer in nearshore seagrass habitats is Phyllaplysia taylori, a sea hare living on Zostera marina eelgrass blades. This sea slug has broad physiological tolerance of both hot and cold temperatures and extensive variation in thermal tolerance traits across its range from Baja California to Vancouver B.C. However, it appears cold extremes are more likely to limit the grazing ability of P. taylori, while hot extremes increase the variation among individuals within a single population, in addition to limiting reproductive success. Both hot and cold extreme temperatures are likely to increase in temperate intertidal zones, suggesting that the effective grazing service provided by P. taylori individuals may become unpredictable with climate change. While unpredictable individual responses lead to high variation within a population, diverse strategies in response to temperature will allow sea hare populations to continue providing essential grazing services on the whole throughout projected future climate scenarios.

SURFPERCH BRAINS ON ACID: IMPACT OF ACIDIFICATION ON FISH BRAIN GENE EXPRESSION OUTWEIGHTS THAT OF UPWELLING-SCALE PH VARIABILITY (YOUTUBE)
† Toy, J.A.1; Logan, C.A. 2; Bernardi, G. 1; Takeshita, Y. 3; Kindinger, T.L. 1; Kroeker, K.J. 1

1- University of California, Santa Cruz 2- California State University, Monterey Bay 3- Monterey Bay Aquarium Research Institute

Ocean acidification has been identified as a major threat to the structure and function of marine ecosystems through direct and indirect effects on constituent species. Many studies have now documented significant impacts on a variety of marine species, especially calcifying invertebrates and algae. Notably, a number of recent studies have documented changes in the cognitive function of tropical marine fishes when pH is experimentally lowered, raising concerns about related shifts in species interactions. Here, we investigate whether this hypothesis of broad neurological impacts holds in temperate Pacific fish, which experience regular upwelling events that temporarily lower local ocean pH. In this manipulative laboratory experiment, we tested the effect of acidification, as well as pH variability, on gene expression in the brain tissue of a common temperate kelp forest fish, Embiotoca jacksoni. We found that global patterns of gene expression in brain tissue differed significantly across pH level treatments, and a small number of specific genes were differentially expressed between static pH and variable pH treatments. In total, we found 200 genes were significantly differentially expressed across all treatments, including genes related to ion transport, signalling pathways, and neurotransmitter regulation.

Poster Presentations
* indicates presenting author, † indicates eligibility for Best Student Paper Award
Parasites have the potential to strongly affect population dynamics, so it is important to consider parasite infection data when attempting to understand the ecology of a species. Despite the fact that the hermit crab *Pagurus hirsutiusculus* is extremely abundant in the intertidal zone, its array of parasites have gone relatively unnoticed and understudied. We conducted field surveys to detect the presence and estimate the prevalence of parasites in *P. hirsutiusculus* at sites in southwestern British Columbia along with Calvert Island on the B.C. central coast. We also selected five sites in the lower mainland of B.C. to identify seasonal prevalence trends. Preliminary results suggest that salinity and wave exposure levels may play a role in influencing the parasite species present and their prevalence at a site. Through the course of our work, we found three externally visible parasites. Two of which we have tentatively identified as the colonial rhizocephalan *Peltogasterella gracilis* and the branchial isopod *Eremitione giardi*, with DNA sequencing planned to verify these morphology-based identifications. The third parasite has been confirmed through sequencing to be a Peltogastrid rhizocephalan which is yet to be described. The contribution of parasites to local diversity has been understudied, which represents both a challenge and an opportunity to better understand the drivers of local biodiversity.

**ASSESSING THE TROPHIC AND FACILITATIVE RELATIONSHIPS OF A NON-INDIGENOUS ANEMONE SPECIES**

† Andersen, M.N.; Harley, C.D.G.

*University of British Columbia*

The orange-striped green anemone, *Diadumene lineata*, is a widely distributed clonal species that has been introduced to coastal habitats around the globe. Although its distributional patterns and reproductive biology are increasingly well established, little is known about its ecological impacts on indigenous species. The purpose of our study is to establish *D.lineata*’s position in the intertidal communities of British Columbia, where the anemone is widely distributed and locally abundant. Field and laboratory experiments are underway to determine ecological interactions. Preliminary results suggest a generalist diet including, zooplankton, small molluscs, and a variety of terrestrial arthropods. The average natural area density in high shore tidepools at our study site was found to be four individuals per 10 cm². These densities have been manipulated and pools are censused for change in Shannon diversity on an ongoing basis. Observed association between mussels and anemones in these pools have informed a field-based mussel density manipulation to determine the degree to which mussels may facilitate *D.lineata*. Additionally, experiments are planned to investigate whether anemones may benefit mussels by deterring predation by sea stars. Coupled with these experiments, we are conducting feeding trials in the laboratory to explore dietary breadth and vulnerability to indigenous predators. Ultimately, our findings, as they relate to *D.lineata*’s ecological influence, will inform whether the species should be properly classified as an invasive species in British Columbia.

**DOES PREDATOR PRESENCE INFLUENCE ANAEROBIC METABOLISM AND BEHAVIOR IN THE ACORN BARNACLE BALANUS GLANDULA?**

† Anderson, K.N.; Dotterweich, M.M.; Hardy, K.M.
The acorn barnacle, *Balanus glandula*, has been shown to exhibit tidal zone-dependent differences in anaerobic capacity and cirral behavior. Specifically, barnacles in the low intertidal had higher lactate dehydrogenase (LDH) activity and spent less time cirri beating while submerged than conspecifics from the high intertidal. We hypothesize that increased LDH activity in low intertidal *B. glandula* results from increased predator exposure, and thus more prolonged shell closure, during longer periods of immersion. To explore this, we measured the density of *B. glandula* and the predatory snail *Acanthinucella spirata* across tidal heights at several intertidal sites in California. And in the lab, we compared barnacle cirral activity in the presence and absence of *A. spirata*. We found the density of both barnacles and snails was significantly higher in the low intertidal relative to the high at all field sites. Further, 10% fewer barnacles were feeding during the first 1.5h of predator exposure, compared to unexposed barnacles, though this pattern disappeared by 24h. This led us to question the universality of the tidal height effects on LDH and cirral beating in *B. glandula*. Unfortunately, we couldn’t replicate a relationship between tidal height and LDH activity when measured at several intertidal sites. Barnacles from the high intertidal, however, still engaged in more cirral beating than those from the mid or low. Thus, effects of tidal position on anaerobic metabolism in *B. glandula* may not be pronounced, though feeding behavior is still linked to tidal height.

**FIRST ANALYSIS OF MULTIPLE PATERNITY IN THE BLUE SHARK**
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The international shark-fin trade is supplied by both the legal and illegal trade of up to 100 million individuals annually. The blue shark, *Prionace glauca*, one of the most abundant and widely distributed shark species, is estimated to account for nearly 10-20% of the annual global catch in sharks and is a highly desired species for the shark fin trade. Understanding mating systems and their influence on population dynamics is critical in conservation and management programs, particularly for over-exploited species. Multiple paternity (MP), a widely recognized reproductive strategy in a variety of elasmobranch species, has not been investigated in blue sharks to date. Therefore, to assess MP in this species, DNA was extracted from muscle samples of 12 dams and their litters for further STR-genotyping. We tested seven polymorphic loci for single-sire exclusion and estimation of relative sire contribution in each litter. Our results suggest that multiple-sired litters are common in the blue shark with 83% of the litters sired by at least two individuals. In highly migratory species such as blue shark, multiple paternity might increase the effective population size and buffer the loss of genetic variability in global panmictic populations, thus reducing the risk of extinction.

**A META-ANALYSIS OF THE INTERACTIVE EFFECTS OF OCEAN WARMING AND ACIDIFICATION ON MARINE ECTOTHERM PERFORMANCE**
† Beaty, F. L.; Calvo, L ; Harley, C. D. G

*University of British Columbia*

Ecophysiological theories aiming to predict the impacts of climate change on organismal performance are often challenged due to the complex nature of organismal sensitivity and stressor
interactions. For example, theories such as the oxygen- and capacity-limited thermal tolerance (OCLTT) predict that ocean acidification and warming interact synergistically to limit thermal windows for marine ectotherms. However, studies that have synthesized the interactive effects of these two stressors consistently demonstrate varied outcomes that depend upon life-stage, taxonomic group, and temporal exposure. Here, we conduct a comprehensive meta-analysis of the effects of ocean acidification and warming on marine ectotherms to quantify support toward OCLTT predictions. To date, we have selected and extracted data from 67 papers from Web of Science (2016-2018) that align with our inclusion criteria. Upon completing our database formation, we will calculate mean effect sizes for sublethal and lethal response variable categories (e.g. growth, reproduction, survival) across taxonomic groups and life-stages. We will also calculate a paired mean effect size to quantify whether the stressors have a greater impact on sublethal or lethal responses and to estimate the overall prevalence of non-additive interactive effects (e.g. synergistic, antagonistic). This synthesis will provide an overview of the specific sensitivities of different life stages and taxonomic groups to ocean acidification and warming, and will contribute toward the ongoing evaluation of the OCLTT’s predictive application.

INTEGRATED DATA IN INVASIVE SPECIES MANAGEMENT
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Memorial University of Newfoundland

The European green crab (Carcinus maenas) is a formidable competitor that has invaded nearly every continent with numerable environmental and ecological impacts. Several regions are actively mitigating invasions to reduce biodiversity pressure. Due to a wide range of tolerances and generalist characteristics, mitigation efforts have been mostly unsuccessful. As such, populations continue to spread. Here, we use integrated global time-series data to model over 100 years of satellite temperatures and green crab abundances to detect an exploitable physiological weakness. Using mixed-effect models in a meta-analytic framework, we show a negative correlation between summer sea surface temperatures and C. maenas abundance. Populations declined following hotter-than-average summers, suggesting a potential limiting factor in the juvenile life stage. From a management perspective, targeting mitigation efforts in summers of above-average heat (e.g., El Niño) may increase eradication success. This research shows the power of integrated biodiversity data in providing unexpected insights.

SEA OTTERS REDUCE BENTHIC MESOPREDATOR PREDATION IN SOUTHEAST ALASKA SEAGRASS COMMUNITIES
† Borup, M. D.1*; Raymond, W. W. 2; Eckert, G. L. 2

1- University of Alaska Southeast 2- University of Alaska Fairbanks

Seagrass (Zostera marina) meadows are abundant nearshore ecosystems in Southeast Alaska, acting as nurseries for fishes and crabs, and play an important role in nutrient cycling and substrate stabilization. The growing sea otter population near Prince of Wales Island has negatively affected crab populations which are common mesopredators in seagrass communities. However, the effect on overall predation pressure by mesopredators in seagrass ecosystems is poorly understood. To test if sea otters change the intensity of predation by crabs and other benthic predators, we performed a simple predation assay modeled on the commonly used “squidpops” in seagrass beds across a gradient of sea otter density. We deployed 25 squidpops with standardized baits placed at the top and bottom of 0.5 m stakes at 23 sites for 24 hours and recorded bait presence or absence. Higher proportions of bottom baits were absent at low sea otter sites. Top baits were rarely absent across all sites. These results suggest that benthic mesopredator activity in Southeast Alaska
seagrass beds is greater than epibenthic mesopredator activity, and that benthic activity is lower in high otter sites. Opportunistic videos taken of squidpop deployments indicate crabs consuming bottom baits, however cannot completely confirm that they are the sole mesopredators feeding in the system. This study supports the hypothesis of sea otter mediated trophic cascades, as it appears that sea otter presence decreases mesopredator consumption.

INGESTION AND ASSIMILATION OF MICROPLASTICS IN PACIFIC SARDINES, SARDINOPS SAGAX, WITHIN THE SOUTHERN CALIFORNIA BIGHT.
Bowers, C.M.*; Paig-Tran, E.M.

California State University Fullerton

Microplastics (MPs; 20 µm to 5 mm) are ubiquitous emergent pollutants in marine environments. Major sources of MPs stem from anthropogenic plastic-littered effluent draining into coastal waters worldwide. The Southern California Bight (SCB) is inhabited by subpopulations of Pacific sardines (Sardinops sagax), a commercially important fish for bait and animal consumption. Pacific sardines filter-feed on zooplankton within the same size range as marine MPs and are therefore, vulnerable to ingestion. We aimed to: 1) examine the presence of contaminated MPs in surface coastal waters at four locations in the SCB, 2) determine whether sardines were ingesting MPs and, if so, 3) determine if the ingested MPs were then assimilated into body tissues. MPs were extracted and quantified from ocean surface water samples offshore from LA Harbor, Palos Verdes, the mid-channel between LA Harbor toward Catalina Island, and the western side of Catalina Island; and collected sardines from the San Pedro bait barge. We found that surface coastal water samples from LA Harbor had more MPs (average 43/L) compared to other sights in the SCB channel and near Catalina. Sardine stomachs contained MP contamination (primarily in the form of microfibers). In addition, we found microfibers in the muscle tissue; however, the number of MPs in the liver was negligible. Our study builds on previous MP studies of muscle tissue contamination in canned sardines. This study definitively shows that MPs’ presence in the muscle tissue occurs in wild-caught fish and is not from the canning process.

TIMING FLOWER COLLECTION IS KEY TO MAXIMUM SEED YIELD: A STUDY IN RESTORING ZOSTERA MARINA WITH SEEDS IN THE SAN JUAN ARCHIPELAGO
Brown, I.M.1*; Wyllie-Echeverria, S. 2; Crow, R. 3; Ramsey, M. 4

1- Santa Clara University 2- University of Washington 3- University of Virginia 4- San Juan Island Conservation District

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 broadcast seeding. The separate phases of seed dispersal include determining the time of season to harvest in order to obtain maximum seed yield, and appropriate season of dispersal to achieve restoration success. While data will be collected on restoration success during the spring of 2021, this current study focuses on harvest time and correlating seed yield. Based on field collections in summer 2020 in the San Juan Archipelago, we found seed yield was 2.9 fold higher (independent two-tailed t8 = -2.63,
(p=0.030178) in flowering shoots collected on July 6 & 7 when compared to those collected on June 22 & 23.

**ASSESSING THE EFFECT OF EUROPEAN GREEN CRAB RELATIVE TO EELGRASS DENSITY**
† Brown, K.A.*; de Rivera, C.E.

*Portland State University*

Eelgrass (*Zostera marina*) plays a critical role in estuarine ecosystem function by sustaining a variety of marine and freshwater species, but it’s increasingly threatened by the invasive European green crab (*Carcinus maenas*). *C. maenas* abundance is on the rise within the coastal environment of Oregon and it’s imperative to know how these populations will affect the long-term health of eelgrass. *C. maenas* is known to pull out eelgrass when hunting for invertebrate prey underneath. Our goal is to understand to what extent the density of *Z. marina* affects its likelihood of persistence despite bioturbation by *C. maenas*. We conducted our study in Netarts Bay, OR using 0.5m^2 enclosures to analyze change in eelgrass cover over the span of two weeks. We expect to find that high density *Z. marina* can withstand bioturbation due to *C. maenas* up to a certain threshold after which we will see diminished *Z. marina* densities. Results from this study will improve understanding about the effects of invasive species on eelgrass health, which will inform future management decisions about transplanting methods, areas to prioritize restoration, as well as when and where to prioritize *C. maenas* removal.

**VERIFYING GIANT SEA BASS (**STEREOLEPIS GIGAS**) SPAWNING: THROUGH AUDITORY AND VISUAL OBSERVATIONS**
† Burns, E.H.*; Allen, L.G.; Franklin, M.P.

*California State University, 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. 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. Along with “booms”, GSB have also been observed to display courtship behaviors that have only been seen in spawning aggregations. We hypothesize that GSB vocalization occurs frequently during spawning and is used in combination with courtship behaviors to signal reproduction readiness. This poster explores the in-progress investigation into the hypothesized acoustical and courtship behaviors exhibited by GSB during spawning. Presented is a portion of preliminary data gathered in the summer of 2014, 2015, and 2019. During which, we recorded a novel sound produced by captive GSBs that successfully spawned. I argue that by identifying these behaviors, researchers will be able to verify GSB spawning when these auditory and visual behaviors are observed.

**FUNCTIONAL DIVERSITY OF HABITAT FORMERS DECLINES SCALE-DEPENDENTLY ACROSS AN ENVIRONMENTAL STRESS GRADIENT**
† Cappelatti, L.*; Mauffrey, A.R.L.; Griffin, J.N.

*Swansea University*
Marine habitat formers such as seaweeds and corals are lynchpins of coastal ecosystems, but their functional diversity and how it varies with scale and context remains poorly studied. Here we investigate the functional diversity of seaweed assemblages across the rocky intertidal stress gradient at large (zones) and small (quadrat) scales. We quantified four complementary metrics of taxonomic and functional diversity. With increasing shore height, under species loss and turnover, responses of functional diversity were scale- and metric-dependent: at the large scale, only functional richness (functional space occupied) contracted while at the small scale, all measures declined, with the strongest responses evident for richness-based metrics. Null model analyses revealed that functional richness and dispersion were greater than expected in the low shore but converged with expected values at the more stressful higher shore. These results show that 1) while some dimensions of the functional diversity of these habitat formers can be maintained across zones, at the small – neighbourhood – scale, these assemblages can be especially responsive to environmental stress gradients; and 2) niche-based processes can favour co-occurrence of functionally distinctive species under low stress, magnifying differences in functional diversity across gradients. As assemblages of marine habitat formers face accelerating environmental change, studies using trait databases are needed to elucidate patterns, processes, and ecosystem consequences of community (dis-)assembly across diverse groups.

BIOMECHANICAL PROPERTIES OF INDUCIBLE DEFENSES IN THE EASTERN OYSTER CRASSOSTREA VIRGINICA IN RESPONSE TO PREDATOR CUES
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Inducible defenses are phenotypic changes in organisms due to surrounding biotic and abiotic cues. In bivalves, thickening of the outer shell is one of the primary modes of defense against predators. The eastern oyster, Crassostrea virginica, is an ecologically and economically important species in the US east and Gulf coasts. These animals exhibit high phenotypic plasticity in shell properties, including increases in shell mass, thickness, and strength in response to predator exposure. Here, we assess the structural and biomechanical basis for such changes. Juvenile C. virginica were exposed to cues from its common crushing predator, Callinectes sapidus, for 4 weeks. Shells were then cross-sectioned to enable quantification of thickness and micromechanical properties of the outer prismatic and inner foliated layers of the shell. While predator cue exposure did not affect thickness of the foliated layer, thickness of the prismatic layer was reduced. Specifically, predator cues resulted in a 38% reduction of the prismatic layer thickness relative to the total shell thickness. Micromechanical properties of the shell were not affected by predator exposure. For new growth regions, however, mechanical properties did vary between shell layers; the prismatic layer was consistently harder, but more brittle, than the foliated layer. This suggests a trade-off between foliated and prismatic layer growth when oysters are exposed to predator cues, favoring production of a tough foliated layer over a hard prismatic layer for defense against shell-crushing predators.

EXPERIMENTAL EVALUATION OF ABARENICOLA PACIFICA BURROWING BEHAVIOR: IMPLICATION FOR ZOSTERA MARINA RESTORATION AND EXPANSION
Ryley Crow1*; Megan Dethier 2; Sandy Wyllie-Echeverria 2

1- University of Virginia 2- Friday Harbor Laboratories

Seed dispersal and burial are important processes in the expansion and restoration of Zostera marina (eelgrass). The depths at which seeds are buried are a significant factor contributing to seedling survival. If seeds are buried below 6 cm, it is unlikely that viable seedlings will develop.
Burrowing behavior of infaunal organisms can contribute to seed burial and has the potential to be a positive or negative influence on seedling survival. In this study, a mesocosm experiment tested the relationship between lugworm (*Abarenicola pacifica*) density and eelgrass seed burial. Three treatments (no worms, low-density, and high-density of worms) were used to examine seed burial. Three replicates per treatment were seeded with a blend of mimics and real seeds. After 25 days, three cores were extracted from each replicate and the depths of the seeds were recorded. In the high-density worm treatments, the majority of the seeds and mimics were found buried below the 6 cm critical depth, while in the low-density treatment most were shallower than 6 cm, with most of the seeds in the control treatments remaining at the surface. These results indicate that the density of *A. pacifica* should be investigated in order to predict the success of *Z. marina* expansion and restoration efforts.

**OCEANIC WARMING AND ACIDIFICATION EFFECTS ON THE FERTILIZATION AND SPERM SWIMMING SPEED OF FOUR ECHINODERMS**

† Daleo, M.J.*

*Carleton College*

In an era of climate change, impacts on the ocean environment include elevated temperatures and decreased pH. These effects are amplified in shallow coastal regions where conditions can fluctuate widely. This is potentially important for many nearshore species that are "broadcast spawners", releasing eggs and sperm into the water column for fertilization. I conducted fertilization experiments to assess the effects of multiple environmental stressors (pH/temperature) on sperm swimming speeds and fertilization success in four species of sea urchins and sand dollars. Results suggest that: 1) pH had no effect on sperm swimming or fertilization rate; 2) sperm swam faster under elevated temperatures for all species and; 3) sand dollar fertilization peaked at 14~C, increased with temperature in red urchins, and decreased with temperature in green and purple urchins. These results suggest that the reproductive ecology of broadcast spawners may be more sensitive changes in temperature, rather than ocean acidification.

**THE MICROBIOTA OF INTERTIDAL MACROALGAE FUCUS DISTICHUS IS SITE SPECIFIC AND RESISTANT TO CHANGE FOLLOWING TRANSPLANT**

† Davis, K.M.*; Mazel, F.; Parfrey, L.W.

*University of British Columbia*

It is unclear how host-associated microbial communities will be affected by future environmental change. Characterizing how microbiota differ across sites with varying environmental conditions and assessing the stability of the microbiota in response to abiotic variation are critical steps towards predicting outcomes of environmental change. Intertidal organisms are valuable study systems because they experience extreme variation in abiotic conditions on tractable timescales such as tide cycles and across small spatial gradients in the intertidal zone. Here we show a widespread intertidal macroalgae, *Fucus distichus*, hosts site-specific microbiota over small (meters to kilometers) spatial scales. We demonstrate stability of site-specific microbial associations by manipulating the host environment and microbial species pool with common garden and reciprocal transplant experiments. We hypothesized that *F. distichus* microbiota would shift to reflect the contemporary environment due to selective filtering by abiotic conditions and/or colonization by microbes from the new environment or nearby hosts. Instead, *F. distichus* microbiotas were stable for days after transplantation in both the laboratory and field. Our findings expand current understanding of microbiota dynamics on an intertidal foundation species. These results may also
point to adaptations of host-microbial associations to withstand short-term environmental variation as a buffer against environmental change.

AN ONGOING QUEST: UNDERSTANDING THE EFFECTS OF COMPETITION BETWEEN JUVENILE NEREOCYSTIS LUETKEANA AND SARGASSUM MUTICUM

Dobkowski, K.A. 1; Turner, M.S. 2; Calhoon, J. 1; Dittrich, M. 3; Johnson, K.H. 1; Dethier, M.N. 2

1- Bates College, Friday Harbor Labs 2- University of Washington, Friday Harbor Labs 3- University of Alaska Southeast, Friday Harbor Labs

Bull kelp (Nereocystis luetkeana) distribution and abundance are changing in some parts of the Salish Sea as well as other parts of its broad range, from Alaska to central California; this species is an important primary producer and crucial habitat for economically and ecologically important species. While multiple factors may contribute to these shifts, increasing competition from a non-native (but often abundant) species of seaweed (Sargassum muticum) may be a contributing factor. To test the effect of S. muticum (a perennial species) on juvenile N. luetkeana (an annual species), we transplanted small N. luetkeana (stipe < 30 cm) AND S. muticum onto concrete blocks in a factorial-design experiment: S. muticum only, N. luetkeana only, and S. muticum AND N. luetkeana together (n=5 per treatment). We deployed this experiment three separate times between June and August 2020, once in the shallow subtidal near Friday Harbor Labs (FHL) and twice suspended from the FHL floating dock, both times at a depth of ~3 meters. Although we could not assess the differences in growth of transplanted seaweed because of the unanticipated damage they sustained (despite a switch from benthic to suspended “substrate”), we learned that there are likely numerous influences on growth, including herbivory and water motion. However, an important unanswered question remains – how CAN we assess whether S. muticum influences the growth of N. luetkeana? We seek to solicit feedback from the WSN community about what we can do differently to successfully address this question.

SIZE DISTRIBUTION VARIABILITY IN PACIFIC BLUE MUSSELS MYTILUS TROSSULUS IN GLACIALLY INFLUENCED ESTUARIES

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1- University of Alaska, Fairbanks 2- NOAA Kasitsna Bay Laboratory, National Centers for Coastal Ocean Science

Pacific blue mussels Mytilus trossulus are abundant filter feeders that connect the water column and the benthos, provide complex habitats for benthic organisms, and serve as a food source to higher trophic level species. High latitude estuarine watersheds with glacial coverage are more heavily influenced by the influx of cold freshwater than watersheds that are exposed to rain-fed riverine or oceanic influence. Dynamic and/or static environmental conditions may affect size frequency distributions of blue mussels in these variable watersheds. This research seeks to answer the question: how do mussel size frequency distributions change spatially in high latitude estuaries with and without glacial influence, and which environmental variables correlate to this variation? Mussels were randomly collected in May 2019 in two regions in the Gulf of Alaska from a total of 15 sites with varying hydrographic influence and mussels measured. For each site dynamic and static environmental variables were quantified. Mussel size frequencies grouped by sites based on water type: oceanic, riverine, or glacial. Level of glacial influence had no significant effect on mussel size frequency. Analysis of temperature and salinity revealed no significant differences in association with mussel size frequency. Preliminary results suggest that slope is the best correlate with size frequency. This study of how foundation species are affected by changes in environmental
conditions provides deeper understanding of how high latitude nearshore ecosystems are changing in response to a changing climate.

**TALKING TRASH: WILL A TRASH INTERCEPTOR IN NEWPORT BAY, CA INTERCEPT WRACK SUBSIDIES, TOO?**

Eckholdt, K.M.*; Zacherl, D.C.

*CSUF*

Wrack is a cross-boundary subsidy moving between terrestrial and marine environments. It is an important source of nutrients, shelter, and food to coastal communities, boosting biodiversity. Wrack subsidies, including the relative proportions of marine versus terrestrial inputs, have rarely been quantified in estuarine habitats and no data exist on their composition in Newport Bay, CA. Quantification is important because a trash interceptor installation is planned at the mouth of San Diego Creek which feeds into Newport Bay, with potentially positive reductions in trash but unknown and potentially profound effects on organic subsidies. Since Feb. 2020, using randomly-placed quadrats along transect swaths within the wrack zone, we quantified wrack subsidies and trash inputs into Newport Bay at two sites at least once-monthly during the highest spring tide of the month and/or immediately following significant rain events. Wrack was air-dried, sorted to the lowest taxonomic level, and weighed; trash was air-dried, sorted into broad categories, counted, and weighed. Preliminary results suggest that wrack biomass is dominated by terrestrial subsidies; trash inputs are numerically dominated by styrofoam and small plastics. Establishing baseline wrack and trash inputs will allow evaluation of trash interceptor impact on Newport Bay habitats.

**SPATIAL AND TEMPORAL TRENDS IN THE BODY SIZE OF AN INTERTIDAL SNAIL**

† Ellis, W.T.*; Atkins, R.L.; Osenberg, C.W.

*University of Georgia Odum School of Ecology*

Over the past century, mean global surface temperatures have increased approximately 1 degree Celsius, with the overall rate of temperature increase nearly doubling in the last fifty years. Changes in temperature can alter individual physiology and body size, especially in ectotherms, and these increases in temperature will likely alter distributions and abundances and modify interactions with other species. *Littoraria irrorata*, an ectothermic snail, is a prominent consumer in Southeastern salt marshes. Shifts in the body size of *Littoraria* has the potential to affect its metabolic demand and in turn the marsh ecosystem (e.g., productivity and abundance of salt marsh plants). To better understand how temperature influences the body size of *Littoraria* over both space and time we used museum collections of *Littoraria* shells sampled over the past 100 years along the Atlantic coast. First, we quantified how shell traits (i.e., mass and height) changed across latitude and collection year. While we found a significant positive relationship between latitude and shell height, there was no significant relationship between collection year and shell height. Second, we are modeling the relationship between shell morphometry and environmental temperature, which was obtained from NOAA databases of sea surface and atmospheric temperatures. Results will be used to extrapolate past responses to environmental change in temperature to better understand ongoing and future responses to climate change.

**Title: NOT SO SHELLFISH AFTER ALL: HOW NATIVE OYSTERS (O. LURIDA) MAY AID EELGRASS (Z. MARINA) RESTORATION BY NITROGEN FI**

† Emery, M.E.*; Zacherl, D 1; Nichols, K.D. 2

1- CSUF 2- OC Coastkeeper
Eelgrass (Zostera marina) is a foundation species in coastal waters that provide vital ecosystem services ranging from habitat provision to trophic support. However, populations have declined globally at alarming rates including within Upper Newport Bay, CA. A multi-habitat restoration approach with native oysters (Ostrea lurida) may be the key to promoting more successful eelgrass restoration. Oysters may increase nitrogenous nutrients within sediment porewater for uptake by eelgrass by mediating nitrogen transfer from the water column via filter-feeding and subsequently depositing nitrogenous waste into sediments. Resource managers are concerned about the efficacy of co-restoration with native oysters due to potential negative interactions with eelgrass as a protected species. Little research has been conducted to date to address the efficacy of restoring these species together. In summer 2019, we collected eelgrass shoots from four restored sites within Upper Newport Bay using a factorial block design, with eelgrass alone, eelgrass with oysters, oysters alone, and a mudflat control at each site. Shoots were processed for leaf and rhizome growth rates, and above and below ground dry weight. Response metrics were analyzed in relation to distance from and density of respective oyster beds using two-way mixed ANOVAs and linear regressions. Preliminary results indicated no significant associations suggesting a neutral relationship. Further research will be conducted to measure ammonium and nitrate within porewater samples, and percent total nitrogen in eelgrass tissue.

**PHYLOGENETIC ANALYSIS OF CALIFORNIAN SYNGNATHUS PIPEFISHES USING FULL MTDNA GENOMES**

Espinosa, J.A*; Walter, R.P

NA

There are currently five *Syngnathus* pipefishes species recognized inhabiting the Pacific shoreline of California: *Syngnathus auliscus*, *S. leptorhynchus*, *S. californiensis*, *S. euchrous* and *S. exilis*. However, recent work that uses DNA barcoding and morphological inspection suggests that the latter four *Syngnathus* species likely represent a single species. Here, we constructed the complete mitochondrial genomes for the individuals from each of the five *Syngnathus* pipefishes present in southern California waters, and performed Bayesian and maximum likelihood phylogenetic analyses. Our results support the monophyly *S. leptorhynchus*, *S. californiensis*, *S. euchrous* and *S. exilis*, with *S. auliscus* as a sister species to this group.

**GROWTH OF THE INVASIVE SEAGRASS HALOPHILA STIPULACEA IN COMPETITION WITH THE NATIVE SYRINGODIUM FILIFORME IN THE US VIRGIN ISLANDS**

† Farchette, A.1*; Jerris, K. 1; Turner, T. 1; Willette, D. 2; Wyllie-Echeverria, S. 3

1- University of the Virgin Islands 2- Loyola Marymount University 3- Friday Harbor Labs, University of Washington

With the rapid spread of the invasive seagrass *Halophila stipulacea* throughout the Caribbean Sea, the impact on native seagrass communities is one of many questions that needs to be answered. Our study looks at the interaction between *H. stipulacea* and one of the major native seagrasses found in the United States Virgin Islands, *Syringodium filiforme*. Beginning in June 2020, we observed the effect competition had on shoot density, blade length, and percent cover of both species in Lindberg Bay, St. Thomas at 2.5-3 m depth. Using an in-situ transplant experiment we found that there may be a positive effect on *H. stipulacea* when growing alongside *S. filiforme*. Blade length did not significantly differ between those growing adjacent to each other when compared to those growing by themselves in either species; but *H. stipulacea* had a significant increase in shoot density (T-Test, p=0.01669) and a significant increase in percent cover (T-Test, p=0.002875) in the
presence of *S. filiforme*. Our results suggest that *S. filiforme* may facilitate the spread of *H. stipulacea* as it invades new habitats in the Caribbean Sea.

**EXAMINING THE INFLUENCE OF LOCATION, LENGTH, AND YEAR ON SEX RATIOS OF LINGCOD (OPHIODON ELONGATUS)**

Fox, M.M \(^1\); Brauer E. \(^2\); Waltz G. \(^2\); Buchheister, A. \(^1\); Marrin Jarrin, J.R \(^1\); Wendt, D. \(^2\)

1- Humboldt State 2- Cal Poly

Lingcod, *Ophiodon elongatus*, a benthic species along the Western Coast of North America, is an important recreational and commercial groundfish species. Total commercial Lingcod catch has declined from approximately 3 million pounds in the 1970’s and 1980’s to approximately 314,000 pounds in 1999. Starting in 2007, the State of California implemented marine protected areas (MPAs) as an additional management tool for nearshore fish stocks, respectively making up approximately 16% of the state waters with 9% as no-take marine reserves. Fishing pressure has been shown to affect numerous life history traits in fish, such as age and size at maturation, an important management metric. We wanted to investigate whether fishing pressure might also have an effect on sex ratios in Lingcod and tested whether a marine protected area (MPA), length of fish, catch location, and year had an influence on Lingcod sex ratios. Fish were sampled inside of MPAs and in adjacent unprotected reference sites during California Collaborative Fisheries Research Program research trips that have taken place annually since 2007. A binomial general linear model was used to test the effect of protection status, location, year, and length on the likelihood that a Lingcod was female. We found that Lingcod were almost always female above 76 cm and spatial differences in Lingod sex ratios between our two sampling locations. This is potentially important because anglers target larger Lingcod and thus could depress the reproductive output of the population through preferential selection of larger female Lingcod.

**PHOTOGRAMMETRY-BASED MEASUREMENTS OFFER INCREASED RESOLUTION IN UNDERSTANDING CORAL-SYMBIONT RELATIONSHIP**

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Successful integration of novel technology and ecology requires clear understanding of how new methodologies improve our interpretation of biological processes. In marine systems, recent advances in photogrammetry software allow scientists to turn high volumes of still images into 3D renderings of field sites in the hopes of facilitating ecological investigations. Yet it remains unclear whether these high resolution models offer greater insight into the way animals interact with their habitat than the basic tools we have used to date. Here we compare the benefits of using these 3D renderings to traditional field measurements of coral size and morphology and test the hypothesis that 3D models can help us better predict the link between habitat and biodiversity. As a case study, we used the coral *Pocillopora* and the community structure of its associated symbiotic fish and invertebrates. We show that coral skeletal volume measured via photogrammetry explained twice as much of the observed variation in symbiont abundance and richness within coral colonies than ellipsoid coral volume estimated using manual measurements. We additionally show how photogrammetry can offer unique coral morphology metrics that may influence fish and invertebrate abundance and richness. This study demonstrates how photogrammetry is a promising tool for linking biodiversity to marine habitats by providing a more precise understanding of ecological features and fine scale variation in the biodiversity of primary habitat space holders.
WATER FLOW AND ASSOCIATED INVERTEBRATES MODULATE AGAL DIFFUSIVE BOUNDARY LAYERS
† Glanz, J.S. *; Carpenter, R.

California State University, Northridge

Macroalgae can modify the chemistry of their diffusive boundary layer (DBL), a microenvironment above their surface, through metabolic processes. DBL thickness ranges from µm’s to mm’s, depending on water flow rates, and associated mobile invertebrates may be small enough to live within this zone. At night, algal respiration reduces DBL oxygen and pH. This can be exacerbated in flow-protected areas where thicker DBLs develop and mass exchange with the surrounding seawater is slowed. However, mobile invertebrates may further influence DBL formation through their respiration or movement. In this study, oxygen and pH profiles were measured within the DBL of a branch-forming species of crustose coralline algae with and without associated invertebrates. These were performed at night under 3 flow speeds (0, slow: 2, fast: 15 cm s^-1) and DBL thicknesses were calculated. As expected, increased water flow significantly thinned the DBL and minimized differences in chemistry from the surrounding seawater. In static flow, hypoxic conditions and thicker DBLs were more frequent on algae without invertebrates present. These results suggest that water flow, induced by physical forces or mobile invertebrates, can mitigate low oxygen concentrations detrimental to algae and associated assemblages at night.

HIGH ENERGY BOAT WAKES NEGATIVELY IMPACT OLYMPIA OYSTER (OSTREA LURIDA) BEDS CONSTRUCTED FOR LIVING SHORELINES PROJECT
† Goodwin, V.G. *; Zacherl, D.C.

California State University, Fullerton

Significant development in Southern California coastal areas has removed marine habitat that would normally buffer wave energy, leaving shorelines vulnerable to erosion. Living Shorelines projects address this problem by restoring native habitat to rebuild ecosystems in a way that provides ecosystem services such as shoreline stabilization. Foundation species such as oysters and eelgrass are increasingly used in these projects because they provision habitat via their three-dimensional structure and reduce erosion. Native Olympia oyster, Ostrea lurida, beds and eelgrass, Zostera marina, beds were restored at four sites in Upper Newport Bay in 2016 as part of the Upper Newport Bay Living Shorelines Project to explore combined benefits of restoring two foundation species. We have recorded differential success across sites in terms of oyster density and bed growth. Human activity such as trampling and wave energy has been previously linked to mussel and oyster bed degradation, so to understand the impacts of human activity on restored oyster beds I conducted 30-minute human use surveys at all sites and documented all instances of human activity including recreation, fisher activity, boating, and the size of wakes produced by each passing boat. Preliminary analyses show a trend for reduced oyster density with increased frequency of large boat wakes and a trend for increased oyster density with kayak and paddleboard activity, likely because these activities occur primarily within a marine reserve. This information will inform site selection for future restoration efforts.

EFFECTS OF ECOLOGICAL COMMUNITY CHARACTERISTICS ON CORALLIVORY INTENSITY IN THE CARIBBEAN
Hale, T.H. 1*; Barton, E.M. 1; Rempel, H.S. 1; Ruttenberg, B.I. 2
Parrotfishes are important herbivores that indirectly facilitate coral recruitment and growth by grazing algae on coral reefs. However, some parrotfish species also prey on coral, which can cause partial to total colony mortality and reduce growth and reproduction of corals. We examined the relative intensity of parrotfish predation on reef-building corals across gradients in reef community composition at multiple spatial scales on reefs in St. Croix and Bonaire in the Caribbean. At each site, we surveyed: (1) parrotfish biomass, (2) percent cover of coral and algae, and (3) the abundance and size distribution of parrotfish bite scars on coral colonies in relation to coral species and size. We used linear mixed models to compare (1) the likelihood of predation scars being present within a transect, (2) the incidence of scars per colony, and (3) the size of scars per colony in response to site-level differences in parrotfish biomass, algae cover and coral cover. We found colony size to be the only significant driver of corallivory intensity, while there was no effect of parrotfish biomass, coral cover, or coral species. These findings suggest that corallivory intensity is not strongly influenced by site-level patterns in coral cover or parrotfish biomass and is, instead, more strongly influenced by traits of individual colonies. This study improved our understanding of how changes in coral reef community composition on increasingly impacted reefs may alter the intensity of parrotfish corallivory, as well as species-specific differences in corallivory rates.

EXPLORING RECRUITMENT VARIATION AND HABITAT CONDITIONS THAT SUPPORT OLYMPIA OYSTER RESTORATION
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Recruitment limitation is a significant challenge that constrains populations with low adult densities. Recruitment density and reliability are essential attributes for evaluating population trends and resilience. Olympia oyster (Ostrea lurida) recruitment dynamics are highly variable in space and time. At some California estuaries, including the Elkhorn Slough, recruitment failure is common and is preventing population recovery. Understanding which factors predict recruitment is critical for designing conservation and restoration strategies. To understand drivers of recruitment rate, we investigated variation in recruitment and environmental parameters at 9 sites in Elkhorn Slough and 14 in San Francisco Bay. We hypothesized that some environmental factors would positively affect recruitment (warm water temperatures, high chlorophyll concentrations) and others would negatively affect recruitment (frequent hypoxia, high sedimentation rates). We conducted univariate and multivariate analysis to explore the relationship among these variables and recruitment rates. Our results will help inform site selection for oyster restoration projects, as well as suggesting improved wetland management strategies.

UNDERSTANDING THE EFFECT OF LIVING SHORELINE PROJECTS ON THE ECOSYSTEM SERVICES OF EELGRASS TO ENHANCE THE OUTCOMES OF RESTORATION
† Hendrickson, C.I.†; Boyer, K. E.; Nielsen, K. J.

San Francisco State University
Seagrasses provide numerous ecosystem services: protecting shores via sediment stabilization, contributing to carbon storage via organic matter burial, and locally increasing pH (countering acidification) during periods of active photosynthesis. They are threatened worldwide, largely by human-mediated impacts, prompting restoration efforts. Living shorelines projects (LSPs) in the San Francisco Estuary aim to restore habitat while protecting shores. Prior work has shown that installation of LSP reef structures, designed to attract native Olympia oysters (Ostrea lurida), also benefits plantings of the seagrass, Zostera marina (eelgrass). Eelgrass planted on the shore side of these reefs became taller and denser than those planted on the bay side or those planted alone. The magnitude and spatial extent of the reef protection effects, including wave attenuation, increased sedimentation, and increased water residence time, on eelgrass are not well understood. At two LSP sites, plaster dissolution blocks supported previous findings that the reefs reduce wave energy, and suggest that the site with stronger wave energy has a larger attenuation shadow. Sediment cores showed higher organic matter deposition leeward of the reef, but we also observed lower deposition within 1 m of the reef. Drone footage tracking particles (oranges) found areas of higher residence time leeward of the reef. Understanding the physical effects of LSP oyster reefs can inform future LSP designs and will help optimize eelgrass plantings to enhance establishment and provision of ecosystem services.

**DO PROPAGULE PRESSURE AND RESIDENT COMMUNITY FUNCTIONAL DIVERSITY AFFECT INVASION SUCCESS?**

† Huynh, E.1*; Chang, A.L. 2

1- San Francisco State University 2- Smithsonian Environmental Research Center

Anthropogenically-mediated invasions are one of the most pervasive issues that coastal systems face today. Extensive research has focused on understanding the mechanisms underlying invasions. I hypothesized that colonization success is a function of both propagule pressure and biotic resistance. Using biofouling communities in the San Francisco Estuary (SFE), I investigated the effects of community functional diversity and invader propagule pressure on the colonization success of a bryozoan, Bugula neritina. I assembled invertebrate communities on PVC panels using functional groups as a proxy for diversity and biotic resistance. Functional groups were classified into 4 morphologies: soft colonial, soft solitary, hard calcareous colonial, and hard calcareous solitary. I controlled propagule pressure by manipulating B. neritina larval abundance in mesocosms containing the 4 functional groups, 1 richness group with multiple functional groups and a bare panel control. I compared the abundance of B. neritina between treatments 20 hours after introducing larvae and after 3 months of field exposure. B. neritina settlement varied across community functional types. Soft solitary, soft colonial, and richness groups exhibited more B. neritina settlement compared to the control and hard colonial sheet group (GLM, p<0.05). Differences in realized propagule pressure from initial settlement largely disappeared after the 3 month field exposure. Post-settlement processes such as shifts in environmental conditions may have overcome initial differences in B. neritina colonization.

**SPECIES-SPECIFIC VITAL RATES IN HAWAIIAN CORALS POCILLOPORA LIGULATA AND PORITES LICHEN**

† Kaholoaa K.H.1*; Rodriguez, C.M. 2; Sandin, S.A. 3; Logan, C.A. 1

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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. To better understand the drivers of such declines, we measured coral vital rates (i.e. growth rate, recruitment, and mortality) across space and time at Kure Atoll in the Northwest Hawaiian Islands. Kure Atoll experienced two massive bleaching events in 2014 and 2015, and another minor event in 2017. Vital rates for two common reef building corals with different life history traits, Pocillopora ligulata and Porites lichen, were evaluated using Structure From Motion photogrammetry and 3D reconstruction tools. We used 2D representations of the 3D models to outline live patches of both species and calculate the change in area of about 40 individual corals per site in 2016 and 2019 during a recovery period. We hypothesized that Poc. ligulata would have a higher growth, recruitment, and mortality rate during bleaching events than Por. lichen because Poc. ligulata is known to be relatively more competitive and faster growing, but less heat resistant. After analyzing each species’ vital rates, we found that the majority of Poc. ligulata underwent growth, while the majority Por. lichen experienced mortality and sparse recruitment. This data suggests that Poc. ligulata may be relatively more resistant to future heat stress under climate change.

THE EFFECT OF TIME OF DAY AND TIDE POOL HABITAT ON ACTIVITY PATTERNS IN JUVENILE TIDEPOOL SCULPIN

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The Evergreen State College

Intertidal fishes cope with a variety of parameters and organisms that affect their daily life and behavior. Temperature, competition, salinity, predators, and oxygen levels are just a few factors that can alter behavioral patterns. Most studies of Oligocottus maculosus, the tidepool sculpin, have focused on adults, so not much is known about the daily behavior patterns of juvenile tidepool sculpin. These juveniles are thought to rely heavily on vision for prey capture, and therefore light intensity can be a driver of their activity patterns. Levels of activity were observed at two sites around San Juan Island, Washington: Friday Harbor Labs (FHL) and Deadman’s Bay. The two sites differed in algal cover within the tide pools and abundance of other tidepool organisms. Frequency of movement and the proportion of sculpins that were active in the open significantly differed between the two sites, most likely due to the differences in algal cover within the pools. Frequency of movement proved to be the best way to characterize level of activity. The Deadman’s Bay site showed a significant increase in frequency of movement in the afternoon time period, indicating that light intensity plays an important role in the activity of the juvenile tidepool sculpin. In the afternoon, the light intensity was greater than in the morning and as long as pool temperature was below sculpin stress levels this created a better environment for successful prey capture. A relationship between the tidepool sculpin and anemones was also explored and proved to be a significant driver of activity.

DENSITY AND ABUNDANCE OF NATIVE AND NON-NATIVE OYSTERS OSTREA LURIDA AND CRASSOSTREA GIGAS OVER TIME IN SAN DIEGO BAY, CALIFORNIA


California State University, Fullerton

Oysters, foundational species in bays and estuaries, provide complex habitat for marine species. Ostrea lurida, the only oyster native to the U.S. west coast, experienced significant population declines during the 1900s and has not recovered since, while Crassostrea gigas, a non-native oyster, was introduced for aquaculture and has since recruited to estuaries outside of aquaculture. C. gigas populations may negatively impact native O. lurida. Over the past decade, C. gigas densities and
abundances increased dramatically in Newport Bay, CA, suggesting that this global invader’s populations may be increasing throughout southern California. We hypothesized that *C. gigas* density and abundance have increased and *O. lurida* density and abundance have declined from 2013-2020 in San Diego Bay, CA. We calculated density and abundance at Chula Vista Wildlife Reserve (CV), Grand Caribe (GC), and Glorietta Bay (GB) at tidal elevations ranging from -0.3 to +1.81 m MLLW. One-way ANOVAs with post-hoc comparisons were used to analyze change in *O. lurida* and *C. gigas* density across years at tidal elevations > and ≤ +0.38 m MLLW. *C. gigas* density and abundance increased at higher tidal elevations at 2 of 3 sites (CV, GB). *O. lurida* density and abundance decreased at lower tidal elevations at 2 of 3 sites (CV, GC). However, *O. lurida* population declines did not coincide with *C. gigas* population increases in space and time. Further studies may elucidate whether population dynamics of *O. lurida* and *C. gigas* are linked over time within San Diego Bay.

**The Complete mitochondrial genome of Dascyllus trimaculatus.**
† Limon, Juliana’; Roberts, May; Schultz, Darrin; Bernardi, Giacomo

UC Santa Cruz

The three-spot damselfish, *Dascyllus trimaculatus*, is a small coral reef fish belonging to the Pomacentridae family whose range extends from the Red Sea to the Pacific. Adults are commonly seen hovering over the reef in pairs, to schools of hundreds, while the juveniles can be found almost exclusively in anemones, often sharing this habitat with the more well-known clownfishes from the genus Amphiprion. The three-spot damselfish is a demersal brooder which likely influences its dispersal ability and therefore its evolutionary trajectory across its broad range. Indeed, *D. trimaculatus* is one species within a well-studied species complex in the Pacific. While much research has been conducted on *D. trimaculatus*, including a number of genetic studies, there has not been an assembled mitochondrial genome published. Here, I present the fully assembled mitochondrial genome of *D. trimaculatus*, the first of any species in the *Dascyllus* genus as a part of my undergraduate thesis. The size of the mitochondrial genome is 18,347 bp in length, with an overall base composition of 26.7% A, 27.6% C, 14.7% G, and 24.7% T. I also confirm *D. trimaculatus*’ evolutionary relationship in the current Pomacentridae family phylogeny by constructing an evolutionary tree using existing mitochondrial genomes from the Pomacentridae family. The availability of this genome can help advance analyses of genetic variability within the species, phylogenetic relationships between *D. trimaculatus* and other fish species, and better understand mutation and speciation rates within the mitochondrial genome.

**CONSUMER PRESSURE INTERACTS WITH RECRUITMENT TO SHAPE ACORN BARNACLE POPULATIONS AT LOCAL AND REGIONAL SCALES**
† Linhardt, S.T.1; Matassa, C.M.1; Corbett, J.2; Whalen, D.2; Trussell, G.C.2

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

Linhardt, Samantha T.^1; Matassa, Catherine M.^1; Corbett, James^2; Whalen, Danielle^2; Trussell, Geoffrey C.^2 samantha.linhardt@uconn.edu 1Department of Marine Sciences, University of Connecticut, Groton, CT 06340 ^2Department of Marine and Environmental Sciences, Northeastern University, Nahant MA 01908 Species interactions can play a strong role in shaping community structure and dynamics. However, because the strength and nature of species interactions is often context-dependent, understanding their relative importance requires experimentation across multiple spatial and temporal scales. For example, the rocky intertidal zone in the southern Gulf of Maine (GoM) has been a model system for studying the role of species interactions in the population dynamics of acorn barnacles (*Semibalanus balanoides*), but recent work has revealed that species
interactions and population connectivity can be quite different in more northern parts of the GoM. Here, we investigate how variation in recruitment and predation pressure interact to influence barnacle populations across the GoM. Our experiment fully crossed a barnacle removal treatment with a consumer exclusion treatment at six exposed headlands spanning from Nahant, MA to Acadia National Park. By examining these interactions across a broad geographic scale, we show how the effects of consumer pressure and intraspecific competition vary across gradients of recruitment intensity arising at local and regional scales.

ASSESSING THE EFFECTS OF MULTIPLE STRESSORS ON SOUTHERN CALIFORNIA EELGRASS TO INFORM STRESSOR MITIGATION AND RESTORATION EFFORTS
Lyford, H.L*; Bittick, S. J.
Loyola Marymount University

Seagrass meadows are ecologically significant habitats currently experiencing massive losses, and are in imminent danger of permanent ecosystem loss globally. These coastal environments provide multiple ecosystem services and have influences far beyond the area of the meadows. Global estimates of seagrass loss hover around 58% for historical study data, however losses may be greater than anticipated. For this study, there was an interest in [A] studying how eelgrasses, more specifically Zostera marina and Zostera pacifica, are impacted by multiple stressors and [B] assessing how current restoration practices can be implemented in Southern California. Current findings display that there is a deficit in studies between seagrasses and other coastal ecosystems, as well as a lack of eelgrass studies taking place on the west coast of the United States. With global recognition for seagrass meadows growing, there is a current need for more studies focusing on good restoration practices and criteria for management decisions to limit anthropogenic impacts on the meadows. This research took place in the form of a systematic map to analyze and track current data and distribution of studies to make recommendations about implementation of restoration goals and inform future studies.

SEAWEED FUNCTIONAL DIVERSITY REVISITED: CONFRONTING TRADITIONAL GROUPS WITH QUANTITATIVE TRAITS
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Swansea University

Seaweed beds and forests fuel coastal ecosystems and are rapidly reorganizing under global change. Yet, quantifying their functional structure still relies on binning species into coarse functional groups on the assumption that they adequately capture relevant underlying traits. To interrogate this ‘group gambit’, we measured 12 traits relating to competitive dominance and resource economics across 95 North-Atlantic macroalgal species. We assessed the functional accuracy and amount of trait variation explained by four commonly used traditional grouping schemes. We then offer an alternative, emergent (post hoc) grouping scheme of macroalgal functional diversity. Traditional schemes explained between about a quarter to a third of multivariate trait expression with extensive group overlap (i.e. low precision) and mismatch with underlying trait expression (i.e. low accuracy). Nonetheless, turf—mainly, sheet and filamentous—species displayed attributes of opportunistic forms. A nine-group emergent scheme provided a highly explanatory and parsimonious alternative to traditional functional groupings. Our study reveals a general mismatch between traditional groups and underlying traits, highlighting the deficiencies of the group gambit. While existing grouping schemes may allow first order approximations, they risk substantial loss of information at the trait and, potentially, ecosystem levels. Instead, we call for further development of a trait-based approach to macroalgal functional
ecology to capture unfolding community and ecosystem changes with greater accuracy and
generality.

DIFFERENCES IN FAUNAL COMPOSITION BETWEEN ACTIVE AND INACTIVE HYDROTHERMAL
VENTS ON THE EAST PACIFIC RISE NEAR 9°50′N
† Meneses, M.J. 1; Mullineaux, L.S. 2; Dykman, L.N. 2; Fornari, D.J. 2

1- University of California, Santa Barbara 2- Woods Hole Oceanographic Institution

Recent volcanic activity within the past decade, including a large-scale eruption in 2005-2006, provides an opportunity to study transient and ephemeral biology of hydrothermal vent communities at the East Pacific Rise (EPR) near 9°50′N. Because most of the submersible dives have focused on communities at active vents, there is a scarcity of data regarding the diversity, abundance, and composition of invertebrate fauna at inactive vent sites, primarily from lack of observational coverage both off-axis and along axis. Inactive vents are considered “extinct” when they are no longer hydrothermally active with no visible effluent into the bottom water, thereby removing the major energy source required to maintain the chemosynthetic ecosystems seen at active vents. High-resolution imagery taken by DSV Alvin during a recent research cruise in 2019 (AT42-21) reveals the presence of benthic megafauna living on and around a newly-discovered inactive, off-axis vent called “Lucky’s Mound” (9.7903°N, 104.2870°W). Due to the significant changes in environmental conditions caused by the lack of hydrothermal fluids, we expect to see a significant change in the composition and distribution of species inhabiting Lucky’s Mound when compared to that of active vents located in the EPR axial trough. Our study analyzes still-images and 4k video to quantify and identify species that inhabit Lucky’s Mound and compare differences in species composition between Lucky’s Mound to Tica Vent, a nearby active vent located at 9.8400°N, 104.2917°W, roughly ~5.5 km from Lucky’s Mound.

Evidence for year round occupancy by gray whales (Eschrichtius robustus) on the Northern Sonoma And Southern Mendocino Coasts
Mercer, Scott N.; Mercer, Theresa

Mendonoma Whale and Seal Study

Since January 2014, we have been conducting an annual census of migrating gray whales (Eschrichtius robustus) as they travel from Northern feeding grounds to their breeding and calving grounds in Baja And the return migration to their northern feeding areas. In addition, we conduct daily surveys of all cetaceans observed and record their presence. In 2016 we began noticing juvenile gray whales foraging in our study area. In the past two years we have begun photo documenting 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. We believe this represents an expansion of the Pacific Coast Feeding Group.

SEASONAL IMPACTS ON THE FAT AND POPULATION CYCLES OF INVASIVE GAMBUSIA AFFINIS
(WESTERN MOSQUITOFISH)
† Courtney Moulton 1; Dr. David Reznick 1; Samantha Levell 1; Samuel Bedgood 2

1- University of California, Riverside 2- University of California, Irvine

The lifecycles of Gambusia affinis (Mosquitofish) have been studied in their native range (eastern United States), where seasonality is prominent, and winters are pronounced. Populations introduced to Southern California face subdued seasonality, and it is unclear how they have adapted. We are studying the seasonal lifecycle, including the fat cycling, of the invasive population
of *G. affinis* in the Santa Ana River. We predict that this population will have a longer reproductive season and either a reduced or no fat cycle. We are also studying the male annual cycle. In native populations, males delay maturation to store fat and overwinter, which leads to seasonal fluctuations in the numbers of immature and mature males. By estimating the numbers of mature and immature males from each collection, we will determine if this trend exists in Southern California’s populations. Our study involves the collection of 100 Mosquitofish each month over the span of a year. Upon collection, the fish are euthanized, preserved, and brought to the lab for processing. Each specimen’s percent of body fat is estimated, and the pregnant females dissected, and their embryos staged. These data are used to determine how nonnative populations have adjusted to the region’s mild climate; their fat cycling will distinguish the amount of time the population overwinters for and how this has influenced the span of their reproductive season. This study can lead to a better assessment of how this invasive population utilizes its resources and impacts the River’s ecosystem, and the native species in it.

**TEMPORAL AND SPATIAL VARIATION IN ABUNDANCE AND SIZE OF THE STALKED BARNACLE POLLICIPE POLLICIPE AT BERLENGAS (PORTUGAL)**

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The stalked barnacle *Pollicipes pollicipes* is intensively harvested on rocky shores of Portugal and Spain and has high commercial value. This species occurs on very exposed shores. Statistical data about this fishery in Portugal underestimate the fishing effort, and there is a need for independent estimates of abundance and size of *P. pollicipes* to be integrated into management decisions. At Berlengas Nature Reserve (RNB), Portugal, a specific management regulation for professional barnacle harvesting was implemented in 2000 (changed in 2011), including size and bag limits, and temporal and spatial closures (no-take zones). The aim of the present study is to evaluate the temporal variation in abundance (percentage cover, density and biomass) and size structure of *P. pollicipes* in 2005, 2011 and 2018/2019 of harvested and no-take zones at RNB (mid and low tidal levels). Two methods for estimating cover of barnacles were used (*in situ* photo-quadrats and low altitude [<5m] drone imagery). Estimates of density, biomass and size were done by destructive sampling of barnacles (15 x 15 cm quadrats located over barnacles, at each tidal level/site; n=3) corrected by mean cover of barnacles at each site/tidal level (random photo-quadrats in situ/drone images, minimum of n=6 per site/tidal level). In the laboratory, barnacles were counted, measured (maximal rostro-carinal length) and weighted. Temporal (2005, 2011 and 2018/2019) and spatial (harvested versus no-take zones) variation of abundance and size of *P. pollicipes* in RNB will be discussed.

**Finding the right home: Depth as a driver of speciation in the genus Sebastes**

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1- California State University Los Angeles 2- NOAA Southwest Fisheries Science Center

This project aims to identify genomic regions that have contributed to ecological differentiation among recently diverged Northern Pacific species pairs from genus Sebastes. We expect depth segregated speciation to result in selective sweeps that generate islands of genomic diversification. We have sequenced exomes from *S. chlorostictus*-S. rosenblatti and *S. crocutulus*-S. miniatus. The
former pair is more recently diverged (0.21 Ma) while the latter pair diverged longer ago (2.3 Ma). Species pairs that are more recently diverged should have more numerous but distinct genomic islands due to the recency of their divergence and contemporary gene flow. Species pairs that are more divergent should have fewer and less recognizable genomic islands across their genomes. The average exome wide Fst (a measure of population differentiation) for S. chlorostictus-S. rosenblatti was 0.02 while the average exome-wide Fst for S. crocotulus-S. miniatus was 0.07. Although exome wide average Fst values are relatively low for both species pairs, they both shared chromosomal regions with elevated Fst values. Finally, nonsynonymous (dn) and synonymous (ds) substitutions were estimated between species pairs to identify loci under positive (dn/ds > 1), neutral (dn/ds = 1) or purifying (dn/ds < 1) selection. Out of 24,093 genes, 1329 genes showed positive selection for S. chlorostictus-S. rosenblatti and 1224 genes showed positive selection for S. crocotulus-S. miniatus. These results provide insight into genomic impacts on speciation in the marine environment.

HANGING BY A THREAD: INVESTIGATING THE EFFECTS OF LOW TIDE TEMPERATURE ON MUSSEL ATTACHMENT STRENGTH
† Oraha, G. R.; Burnaford, J. L.

CSU Fullerton

*Mytilus californianus*, the California mussel, is a foundation species and dominant space-holder in the rocky intertidal zone, an environment that goes through extreme temperature shifts on a daily basis as organisms are submerged in seawater during high tide and exposed to terrestrial conditions during low tide. Previous work has examined how wave action negatively affects mussel attachment. Yet to date, few studies have addressed the role of temperature during low tide on attachment strength of mussels, despite the clear importance of this topic in the context of the rising temperatures predicted with a changing climate. We used laboratory manipulations to investigate how temperature during low-tide affects three components of mussel attachment: byssal thread production, individual mussel attachment strength, and single byssal thread strength. We collected mussels from two southern California field sites and set up a fully factorial seven-day experiment with two types of treatments: number of low tide exposures (exposure on the first day followed by six days of submersion or exposure each day for seven days) and temperature during low tide exposure (ambient or elevated temperature). In the elevated temperature treatment, we used small heaters to individually raise body temperatures by XoC. We predicted and have found that mussels exposed to natural ambient treatments generally have greater individual mussel attachment strength and single byssal thread strength than mussels exposed to elevated temperatures.

Nearshore Fronts as Planktonic Accumulators and Transport Barriers
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Fronts are dynamic boundaries between water masses, often associated with density gradients between lighter, warmer, less saline and heavier, colder, more saline waters. These features can aggregate flotsam and detritus, but also impact the distribution and concentration of marine plankton. The role that small-scale nearshore (1-10 m) fronts play in the transport and distribution of plankton is not well understood. Nonetheless, the ubiquity and proximity to the coast of these features may give them outsized importance in structuring planktonic communities, affecting ecological interactions by concentrating prey for planktivores, and altering dispersal trajectories of planktonic larvae. We present findings from a study of one small-scale front that forms nearshore,
north of Bodega Bay, on the north-central coast of California. Surveys of the front were conducted in spring and summer of 2019 and 2020, using a Tucker trawl plankton net, CTD profiler, ADCP, satellite imagery and time-lapse photography. Plankton were collected at depth and on the surface at 3 locations: onshore of the front, within the front and offshore. We examined planktonic diversity and abundances at all sampling locations. Diversity was consistently higher at the front, which supports prior research showing fronts to be accumulation sites for many varieties of plankton. Further, the front also acted as a barrier or filter, selectively limiting the progress of some plankters across the front according to size, swimming ability, and other characteristics. This research sheds light on the importance of nearshore

**MOVEMENT, AGGREGATIONS, AND HABITAT SELECTION OF GIANT SEA BASS (STEREOLEPIS GIGAS) ALONG THE SOUTHERN CALIFORNIA COAST**

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The giant sea bass, *Stereolepis gigas*, is a critically endangered (IUCN) apex predator that is found in the temperate rocky reef and kelp forests habitats of the Pacific coast. During the summer months, there are several predictable locations in southern California at which this species is known to aggregate, but during the winter, they leave these aggregation sites, most likely traveling offshore to deeper waters. It is thought that they most likely aggregate for spawning purposes, but little is known about their use of aggregation sites from year to year. This study used spot pattern analysis (IS3) to identify individuals and monitor their use of three southern California aggregation sites (Wheeler North Reef, San Mateo Kelp, and Barn Kelp) between 2017 and 2019. During this time, at least 33 unique individuals were identified at these sites, and ten were re-sighted at least once during the three years. Seven individuals were identified at multiple sites, with the most movement occurring between Wheeler North Reef and San Mateo Kelp.

**WELCOME TO THE BENTHOS: INVESTIGATING SPATIAL AND TEMPORAL VARIABILITY IN ABUNDANCE AND PRODUCTIVITY OF BENTHIC GASTROPODS**

† Poulin,E.†; Henkel, S.K.

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The west coast seafloor is a dynamic habitat that is being impacted by both physical and chemical changes due to human activity, and gastropods in this region serve as a valuable indicator of how macrobenthic communities may respond to these disturbances. We are examining if abundance, productivity, or both of the benthic macroinvertebrate community had changed over the course of our study, and, if so, which environmental factors may be causing these changes to occur. Box core sampling was conducted at study sites on the west coast continental shelf during the summers of 2003 to 2016 to collect benthic macroinvertebrates. We used the Brey 2012 model to calculate the productivity to biomass (P/B) ratio of abundant macroinvertebrate species among the various years. We examined how macroinvertebrate abundance and productivity varied over the course of this study in conjunction with factors such as depth, temperature, dissolved oxygen, median grain size, percent fine sediment, dissolved oxygen, and chlorophyll A. We identified significant variance in gastropod abundance and productivity during the 2010-2012 sampling period among the various depth bins, and we found that gastropod species showed a preference for habitats with lower temperatures, a lesser proportion of fine sediment, and a larger median grain size compared to the other macroinvertebrate groups. Moving forward, there is a need for targeted studies to better
understand both how these organisms may respond physiologically to changes in oceanic conditions and the role that gastropods serve in the benthic community.

EFFECTS OF NATURAL AND ANTHROPOGENIC FACTORS ON LARGE MARINE DEBRIS DISTRIBUTION IN PAMLICO SOUND SALTMARSHES
Quackenbush, A.L.; Voigt, E.P.; Eggleston, D.B.

NC State University

Marine debris is persistent, manufactured material discarded or abandoned in the marine and coastal environment. It is damaging to humans and animals because it can entangle marine animals and contains harmful chemicals, which can be ingested and biomagnified through food webs. While many studies have focused on debris found in the ocean and on beaches, few studies examine the amount of debris in other coastal habitats. Saltmarshes provide many ecosystem services and are negatively affected by marine debris. Wave exposure and human population proximity can impact the amount of marine debris found in saltmarshes. The objectives of this study are to (1) quantify the distribution and type of large marine debris (greater than 10 cm) within 8 remote sites along Pamlico Sound as a function of wave exposure, wind exposure, marsh species (invasive vs. native), and human population metrics; and (2) measure the efficacy of drones as useful tools in tracking and measuring marine debris in saltmarsh habitats. This project uses unmanned aerial vehicles, or drones, as a non-invasive method of monitoring marsh debris. Additionally, we completed a ground survey in 2020 to compare our drone survey results to. In both surveys, the amount of debris varies significantly across sites with no clear pattern as to why. In our ground survey, we picked up 218 pounds of debris, totaling almost 2,000 pieces. Knowing what factors predict marine debris distribution and the efficacy of drones to monitor debris will make marine habitat clean-ups more efficient and less invasive.

EVALUATING THE NONCONSUMPTIVE EFFECTS OF GIANT SEA BASS (STEROLEPIS GIGAS)
† Reed, KC

† NA

Giant sea bass (Sterolepis gigas) is one of the few teleost apex predators in the Southern California Bite and the only one that inhabits rocky reefs. This species was fished to ecological extinction in the 20th century; however, in recent years populations have started to slowly recover. This study aims to quantify how the presence of giant sea bass influences the behavior of smaller, mesoconsumer fishes. I am planning to use baited remote underwater video (BRUV) cameras to observe behavior of mesoconsumer in the presence of giant sea bass. Preliminary data from BRUVs suggests that the presence of giant sea bass (an acute threat) changes mesoconsumer behaviors. Further work will characterize how chronic predation risk and habitat structure may influence the relationship between giant sea bass and their prey.

Effects of combined acidification and hypoxia on fast-start response in juvenile rockfish
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1- Cal State Monterey Bay 2- Moss Landing Marine Laboratories, Moss Landing, CA, Stanford University, Stanford, CA 3- NOAA Fisheries, SWFSC Fisheries Ecology Division, University of California, Santa Cruz 4- Moss Landing Marine Laboratories, Moss Landing, CA 5- NOAA Fisheries, SWFSC Fisheries Ecology Division 6- California State University, Monterey Bay
Climate change is expected to intensify wind-driven coastal upwelling in the California Current Ecosystem, exposing nearshore marine organisms to increasing acidification and hypoxia. Juvenile rockfishes recruiting to the subtidal zone during the springtime upwelling season are exposed to further low pH/low DO events. This project seeks to determine the effects of exposure to low pH/low DO on fast-start response behavior in juvenile KGB-C complex rockfishes. Fast-start responses, or sudden accelerations utilized by fishes to avoid predators, may determine the outcomes of predator-prey interactions and therefore are important predictors of survival. To determine how future projected upwelling conditions will impact rockfish fast-start performance, we exposed juveniles to one of three pH/DO treatments for a period of 7 days: control (~8.1 pH, ~8.6 mg/L DO), moderate (7.5 pH, 4.0 mg/L DO), or extreme (7.3 pH, 2.0 mg/L DO). We compared differences in latency effectiveness in relation to treatment. Using the latency of response to a stimulus, we will be able to see if there are any effects of the different environments. This study will help elucidate the species-specific physiological resilience of rockfishes to OA and hypoxia at a critical life history stage. The preliminary results that used image J and pixel calculations to determine distance showed no significant effects of oxygen concentration or pH on any of the locomotive movements of the C start response.

CHARACTERIZING PASSIVE RECORDINGS TO DETERMINE HOW THE SOUTHERN SEA OTTER USES TIDAL CREEKS IN A RECOLONIZED ECOSYSTEM
Sanchez, M.L*; Hughes, B
Sonoma State University

Evaluating the effects of recovering top predators on trophic interactions and habitat utilization can aid scientists in wildlife management and conservation practices. While it is important to monitor large consumers, data collection is almost always limited to observational studies that cannot capture the full breadth of behaviors in their habitat. Passive recording devices present an opportunity to address uncertainties in top predator effects because they can capture events in conditions and habitats not easily accessible for direct observational studies. Southern sea otters (Enhydra lutris nereis) offer a unique opportunity to understand the role of a top predator in a recolonized ecosystem because sea otters have recently re-established in estuarine habitats, such as salt marshes, but their use of these habitats and effects in these communities are not fully known. Here, I propose to address the issue of assumptions and uncertainty of salt marsh tidal creek use by sea otters utilizing camera traps, scat collection, and quantification of crab prey within these creeks. Passive recordings of sea otter activity in three salt marsh tidal creek sites were taken from June 2020 to present. Preliminary data suggests that sea otter presence in tidal creeks has increased in time periods when crab prey counts also increased. Sea otters also utilize the creeks for a variety of behaviors, with foraging and grooming being the most common. Continued monitoring will contribute to an understanding of how and why southern sea otters use salt marsh tidal creeks.

QUANTIFYING SPECIES-SPECIFIC RATES OF COPROPHAGY BY HERBIVOROUS FISHES IN THE CARIBBEAN
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Parrotfishes (Scaridae) and surgeonfishes (Acanthuridae) are major Caribbean herbivores that primarily graze on algae that compete with corals for space, thereby indirectly benefiting reef-
An emerging body of research suggests that nominally herbivorous parrotfishes and surgeonfishes graze on a diverse array of other food sources and researchers have questioned whether some of these fishes may target other food sources within algae substrates that may be more nutrient dense, such as cyanobacteria. However, little work has examined coprophagy, the consumption of fecal pellets, in these species. In this study, we investigated the species-specific foraging rates of parrotfishes and surgeonfishes on Brown chromis (Chromis multilineata) fecal pellets, algae, and other food sources. We found that over 80% of observed C. multilineata fecal pellets were ingested by parrotfishes and surgeonfishes, suggesting that they are directly targeting planktivore feces. We observed nominally herbivorous parrotfishes and surgeonfishes actively foraging on fecal pellets, though rates of coprophagy varied by species. To our knowledge, this is the first study to document coprophagy by tropical herbivorous fishes in the Caribbean region. This research advances our understanding of the importance of fish feces as a nutritional resource on coral reefs and expands our knowledge of the grazing dynamics of these ecologically important herbivores.

**FEMALE AND TAGGED PUP SITE FIDELITY OF NORTHERN ELEPHANT SEALS (MIROUNGA ANGUSTIROSTRIS) AT POINT REYES NATIONAL SEASHORE**

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After being hunted to near extinction during the 1800s, northern elephant seals (Mirounga angustirostris) were first seen at Point Reyes National Seashore (PRNS) during the 1970s. The colony was re-established in the 1980s, during which PRNS researchers began collecting data and tagging weaned pups. Seals have been observed to haul out year round at several sites near the Chimney Rock Headland. In 2016, Dominican University of California (DUC) began collaborating with PRNS. During the 2018-2019 breeding season, our team continued this collaboration. Through weekly observations from January to April, demographic data on total number of seals at each haul out site, gender and age ratios, pup mortality, tag resights, and weather conditions were collected under PRNS permits. Locations surveyed include Drakes Beach (DB), Kenneth Patrick Visitor Center, South Beach, Lifeboat Station and Fish Docks. Previous data collected by PRNS and recent contributions from DUC students were used. The objective of this study was to analyze specific seal behaviors, such as female sight fidelity and tagged pup return rates. It was found that 64% of 242 females returned to the same beach from 2009-2019 and 90.4% of 376 tagged pups identified were seen for 2 years or less, with most tagged pups seen in 1-4 years after being tagged, from 2009-2019. This data shows that seal site fidelity may lead to continued site expansion at PRNS as many seals come back for multiple seasons.

**Genetic identity and connectivity of the Pacific Seahorse population from the Gulf of California**

† Edson Smith-Bejarano; Luis Manuel Enríquez-Paredes; Nelva Victoria-Cota; Jesus Roberto Oyervides-Figueroa; José Alfonso Marmolejo-Rivera

UABC

CITES-documented trade of seahorse species has increased an order of magnitude in the past two decades. However, as evidenced from the large number of seizures, illegal trade outnumbers legal catch and is leading to a global decline of seahorse populations. The Gulf of California Pacific Seahorse (*Hippocampus ingens*) population has been recognized as particularly vulnerable to overharvest as a consequence of low population numbers, bycatch, poaching and some evidence of
low genetic connectivity with other populations. To evaluate the impact of the recent boom in illegal trade on this population, we extended a genetic study from 2010 by analyzing a larger and contemporary sample obtained from a seized shipment in 2017. DNA was extracted from dry tail-clips of 133 individuals and sequenced for 326 bp of the mitochondrial control region. This larger sample allowed the identification of 18 haplotypes at the GOC, including 6 low frequency haplotypes not previously reported for the species. Even when two previously reported GOC private haplotypes were not observed in the contemporary sample, no significant genetic differentiation was found between sampling periods or other areas along the Eastern Pacific coast. Our data provide no evidence for a loss of genetic diversity within the GOC population as a result of a drastic decline in numbers. Updated genetic identity of the Pacific Seahorse is relevant for conservation management plans such as restocking intended-aquaculture.

ASSESSING STALKED BARNACLE PULLICIPES POLLICIPES ABUNDANCE ACROSS EUROPE FOR A STOCK STATUS COMPARISON
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The stalked barnacle Pollicipes pollicipes inhabits very exposed rocky shores from Brittany (France) to Dakar (Senegal) and it is highly prized and heavily exploited in Portugal and Spain. In Europe, several fisheries of this species can be identified with different features and governance/management approaches. None of the fisheries has independent and regular estimates of abundance, therefore a standardized method to assess P. pollicipes abundance along its distribution range is important in order to compare regions and to link the management measures with the status of the resource. The aim of this study was to assess the percentage cover of P. pollicipes in 6 regions along its European distribution in France (1 region), Spain (2) and Portugal (3). In each region, 3 random sites were sampled on the middle of P. pollicipes intertidal distribution (mid shore) by taking photos of random areas (50 x 50 cm; n= 6). Also, the percentage cover of this species on the low shore was accessed in the same sites of 4 regions (Galicia and the 3 regions of Portugal). QGIS software was used for image analyses. Differences among regions and sites were detected. In the mid shore, mean cover of P. pollicipes ranged from <6% in the Central coast of Portugal to 50% in Brittany (France). In the low shore, this species was less abundant, and cover ranged from <3% in Galicia (Spain) to 12% in SW Portugal. Higher cover in Brittany and less cover in Galicia might be related to a higher fishing effort in Galicia comparing to France.

INVESTIGATING THE LINKS BETWEEN ECO-CULTURAL CLAM GARDEN RESTORATION, HABITAT STRUCTURE, AND BIVALVE PRODUCTIVITY
† Spencer, E.R. 1*; Augustine, S. 1; Salter, N. 2; Salomon, A.K. 1
Societies around the world are grappling with the challenge of maintaining food systems that are both productive and resilient to future disturbances. Indigenous management systems provide myriad examples of reciprocal relationships that balance the needs of humans and ecosystems. Clam gardens, intertidal rock-walled terraces made by people, provide one such example, producing double to quadruple the numbers of clams than unaltered beaches. On the Pacific coast of Canada, a Coast Salish led clam garden restoration experiment aims to better understand the drivers behind physical mechanisms that increase clam productivity. As one component of the study, we are evaluating how active beach tending and rock wall reconstruction effect sediment characteristics using a before-after, control-impact design. Following the first five years of restoration, we hypothesize grain sizes will shift towards coarser size classes as the rebuilt wall traps gravel on its landward side and beach tiling increases the transport of silts offsite. Within the same time frame, we hypothesize beach tending will increase carbonate content of sediments via an increase in habitat structure on bivalve biomass and density. Building on previous work that has examined increases to clam production on untended clam gardens, this large-scale study will help explain the effects of human management on habitat conditions and the mechanisms driving variation in clam productivity.

TIMING OF NUTRIENT REGIMES AND COMMUNITY COMPOSITION INFLUENCE GROWTH AND SPECIES-SPECIFIC INTERACTIONS OF MACROALGAE
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Resource variability and community context influence competitive outcomes, which impact species’ distributions and abundances. Resource subsidies can vary in magnitude and temporal pattern, the extremes of which are pressed and pulsed regimes. However, how resource timing affects growth of primary producers is understudied. As coral reefs experience increased nutrients, it is important to understand how different macroalgal species respond to varying nutrient regimes. We used a fully-crossed two-factor mesocosm experiment to assess how three macroalgal species (Padina boryana, Sargassum mangarevense, Galaxaura fasciculata) respond to nutrient regime (ambient, pressed, pulsed) and community composition (alone, in pairs, or all together) in terms of their growth (change in biomass over 12 days). We found nutrient regime and community composition significantly interacted to affect growth for each macroalgal species and for the total community. For example, Padina grew most in pressed nutrient conditions both when alone and with competitors. However, competitor presence mediated Padina growth in ambient and pulsed conditions; Sargassum increased Padina growth in ambient conditions, while Galaxaura decreased Padina growth in pulsed conditions. Overall, different nutrient regimes shifted the relative growth of macroalgal species, which can shift their competitive outcomes and ultimately the community composition. Thus, it is important to assess primary producer species responses to varying nutrient regimes to understand the factors structuring their communities.

GRAZING IMPACTS OF ROTIFER ZOOPLANKTON IN A SEASONALLY CYANOBACTERIA-DOMINATED LAKE
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Vancouver Lake (WA) is characterized by annual and often toxic cyanobacteria blooms. Previous studies have shown copepod grazing to influence bloom formation, and bloom decline to be driven in part by microzooplankton community grazing. However, we don’t understand the individual roles of particular micrograzers such as rotifers. To address the role of rotifers, we conducted feeding incubations with field-collected rotifers. These feeding experiments were performed concurrently with dilution experiments to quantify algal growth rates and microzooplankton community grazing. Preliminary results show that rotifers may have an important grazing effect late in the bloom cycle; however, the impact by the entire microzooplankton community was drastically greater than that of rotifers alone. This indicates that other non-rotifer microzooplankton such as ciliates or dinoflagellates may be the major grazers to influence bloom dissipation. Ongoing analysis is necessary for further interpretation, especially in determining taxon-specific dynamics.

POPULATION GENETIC STRUCTURE AND CONNECTIVITY OF THE ARCTIC’S ANCIENT PREDATOR: THE GREENLAND SHARK
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Greenland sharks (Somniosus microcephalus) are important predators in Arctic waters, yet descriptions of their stock structure and genetic connectivity are largely unknown. Using polymorphic microsatellite markers, we performed population genetic analyses in 256 individuals to uncover intraspecific genetic variation, population structure, and connectivity over multiple spatial scales. Bayesian clustering analyses using LOCPRIOR models and pairwise measures of population genetic differentiation revealed low but significant genetic divergence (FST=0.024, p=0.0001) among sharks found within the Canadian Arctic and outside Baffin Basin. With these data, we were able to uncover two distinct ancestries that correlate with regions found north and south of the Davis Strait, and explore further substructuring within each ancestry. Genotype assignment suggests chiefly asymmetric gene flow into the upper Arctic. This data is among the first to uncover population-level differentiation in sleeper sharks, and is important for understanding the ecology and evolution of this long-lived species.

OCEAN ACIDIFICATION REDUCES FREEZE TOLERANCE IN INTERTIDAL BLUE MUSSELS
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1- The University of British Columbia 2- Université du Québec à Rimouski

Global climate change increases ocean temperatures and causes pH to decline. These environmental changes are causing poleward range shifts and cascading ecological effects. The poleward edge of intertidal marine ectotherms is controlled by their capacity to tolerance sub-zero air temperatures during low tides. Despite the principal importance of freeze tolerance in sessile intertidal species, the underlying physiological processes remain poorly understood. Here we tested the hypothesis that ocean acidification (OA) disrupt cellular homeostasis, hereby increasing mortality in blue (Mytilus) mussels at their poleward edge due to an increased susceptibility to sub-zero air temperatures. Low pH (pH =7.5) significantly reduced freeze tolerance in subtidal and intertidal specimen of M. galloprovincialis and M. trossulus, increasing the lower lethal temperature by more than 3°C from -10.56°C to -8.04°C in intertidal M. trossulus. We moreover investigated and discuss three physiological mechanisms that may explain the depressed freeze tolerance; (1) a destabilized cell membrane caused by variation in the fatty acid composition, (2) variation in the amino acid composition, or (3) differences in the concentration of osmolyte and anaerobic byproducts. Thus, blue mussels are sensitive to pH changes, and further decrease in ocean pH may decrease their
abundance and vertical distribution in cold regions. Finally, sub-zero air temperatures may offset the otherwise facilitative effect of ocean warming on range expansions, resulting in a range squeeze of these habitat-forming species.

**HISTORICAL RECORD OF MACROALGAE IN TOMALES BAY**

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Tomales Bay is a narrow inlet of the Pacific Ocean located in Marin County that lies within the boundaries of both the Point Reyes National Seashore (PRNS) and the Greater Farallones National Marine Sanctuary (GFNMS). Along the shoreline of Tomales Bay, there are numerous locations where rocky substrate supports dense algae stands, including species such as the large brown algaes *Macrocrystis pyrifera* and *Sargassum muticum*. Despite the importance of macroalgae in California’s coastal subtidal communities and conservation value of Tomales Bay within PRNS and GFNMS, comparatively little research has been conducted on these communities. To resolve this knowledge gap, we created a historical record of macroalgae in Tomales Bay to investigate how these communities have changed over the 20th century. Using herbarium records available online at the UC Berkeley and Jepson Herbaria search portal, we collected information on 1017 seaweed individuals collected since 1898. We analyzed the data to see which phylum of seaweed in Tomales Bay is more prevalent, if the number of nonnative species has increased over the years, and which areas did these seaweeds tend to thrive. The results showed only 30% of the Tomales Bay’s seaweed community was introduced and that the seaweed communities were most often sampled at Avalis Beach, White Gulch, Tomales Point and Nick’s Cove. Reconstructing the historical macroalgal community composition of Tomales Bay will allow us to understand how these communities have changed over time and predict the future of these communities under climate change.

**PINTO ABALONE HABITAT ASSOCIATIONS IN SOUTHEAST ALASKA**

† Wang, A.; Iwasaki, N.; Garcia, L.; White, T.

1- co-author 2- mentor

Pinto abalone are a marine gastropod with a large range, from Southeast Alaska to Baja, Mexico. Across this range, pinto abalone were designated as a “Species of Concern,” until the recent suspension of that program, however concerns and data deficiencies remain. To remedy gaps in data, we focused on pinto abalone habitat associations in areas of Southeast Alaska. Specifically, we compared data from 2019 habitat surveys around Sitka, Prince of Wales, and Dixon Entrance, Alaska. In each area, divers took photoplots, along transects of available and used habitat. Each photoplot was then superimposed with a grid of crosshairs, and the biogenic habitat, substrate, and refuge under each crosshair were recorded. Compiled data show that abalone are disproportionately associated with crustose coralline algae, bedrock, and non-coraline crusts. Additionally, abalone were less associated with agarum, an algae that is relatively abundant, but also contains a chemical defense to deter herbivores. Abalone were more likely to associate with boulders and less likely to associate with cobble fields, depending on abalone size. Finally, abalone refuge use was compared in relation to the presence or absence of sea otters, a keystone species. We found that in areas where otters have yet to establish (i.e. Dixon Entrance), abalone were less often in refuge. Our research reflects the habitat types that abalone in Southeast Alaska typically associate with, which gives researchers more context when considering optimal abalone habitats to help support their population.
THE IMPACT OF CLIMATE CHANGE ON METABOLISM, HATCHING SUCCESS, AND VIABILITY OF LINGCOD EGGS IN THE CENTRAL CALIFORNIA CURRENT
† Willis-Norton, E.†; Kroeker, K.J.; Carr, M.H.

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Early life history stages are often more susceptible to physical stressors than the adult stage; however, there is little research on the sensitivity of early life stages to climate change. It is important to understand both the lethal and sublethal effects of shifting conditions for multiple life history stages to gain a full understanding of how a species may be impacted by a changing climate. Lingcod (Ophiodon elongates) is a commercially and recreationally important fish species in the California Current Ecosystem and one of the few species that lays benthic egg masses in the upwelling system. I determined how lingcod’s earliest life history stage may be effected by climate change by collecting egg masses in the field and placing them in a flow-through experimental mesocosm that exposed the eggs to pH, temperature, and dissolved oxygen (DO) levels that are projected by 2050 and 2100 in the Central California Current. Throughout the month-long experiment, I measured the differences in metabolism, hatching success, and larval quality between treatments. This was the first mesocosm experiment that examined the impact of multiple stressors that co-occur for groundfish benthic egg masses in the eastern Pacific Ocean. Hatching success decreased between the current condition (7.85 pH units, 13°C; ~270 μmol/kg DO) and 2050 condition treatment (7.7 pH units; 14.5°C; ~210 μmol/kg DO). There was a more drastic decline in both hatching success and larval quality between year 2050 treatment and year 2100 treatment (7.5 pH units; 16°C; ~150 μmol/kg DO), indicating there may be a tipping point.

RECRUITMENT OF EPIFAUNAL SPECIES TO NATIVE VersUS NON-NATIVE OYSTER SHELLS IN SAN DIEGO BAY, CA
† Wolfe, M. L.; Perog, B. D.; Zacherl, D. C.

CSU, Fullerton

Estuaries modified by human use are suffering from habitat degradation and non-native species introduction. Native species, like the U.S. west coast Olympia oysters, Ostrea lurida, have simultaneously declined. Researchers are investigating the best way to restore O. lurida to stabilize estuarine shorelines and promote community diversity, but they currently co-exist with the globally invasive non-native species, Crassostrea gigas. Multiple studies elsewhere have compared the communities of organisms that recruit to C. gigas shells compared to native oysters, but with mixed results. No studies have compared community diversity on C. gigas versus O. lurida shells. I investigated whether epifaunal species richness differs on O. lurida versus C. gigas shells on replicate rugose baycrete tiles in San Diego, CA at 0 and +0.6 m MLLW. I measured the rugosity of each oyster shell on the underside of each tile, then counted and identified the epifaunal species on the top shell valve of each oyster. C. gigas shells at 0 m MLLW were more rugose than C. gigas shells at +0.6 m MLLW and all O. lurida shells regardless of tidal elevation. O. lurida shells supported higher taxon richness than C. gigas shells at both tidal elevations, with highest richness at 0 m MLLW. O. lurida recruited at higher density to conspecific shells versus C. gigas shells. Community composition differed significantly between species’ shells. Resource managers should promote native oyster recruitment versus non-native oyster recruitment in order to maximize community taxon richness and native oyster density.

SEA SURFACE MICROPLASTICS: AN INSHORE-OFFSHORE GRADIENT OFF THE OLYMPIC PENINSULA
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The lack of data on plastic debris in various environmental compartments creates a vast data gap for many reasons. These include no codified methodology to characterize microplastics by morphology and polymer type, as well as gaps regarding contamination control & validation techniques. In September 2019, sea surface samples were collected off the Olympic Peninsula, WA to address three research questions. First, is variability in microplastic abundance driven by transect location and/or distance from shore? Second, how does microplastic morphology and polymer composition vary relative to transect location and distance from shore? Third, which environmental variables contribute to patterns of microplastic variability in abundance and type? The project provides a distribution-abundance baseline for sea surface microplastics (2-3m deep) along two transects: La Push & Grays Harbor, WA, USA. Organic matter was digested using a KOH solution. After measuring, photographing, and counting MPs via a dissection microscope, lipophilic Nile Red dye (10µg/mL) was applied, MPs were fluoresced at 455nm & counted again. Metrics to count & characterize the MPs found were: size (>63um), color, morphology (fragment, film, fiber, fiber bundle, foam, microbead, other), and polymer type via micro-FTIR. Microplastics count/type, independent environmental conditions, and location data will be analyzed using a t-test. Multiple regression will be used to identify relationships to environmental variables and an NMDS ordination to compare dissimilarity within the multivariate characterization data.

THE EFFECT OF MUSCLE CONTRACTIONS ON GAMETE PLUMES DURING THE REPRODUCTIVE SPAWNING OF THE RED ABALONE, HALIOTIS RUFESCENS
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Free-spawning marine animals, like abalones, need densely aggregated populations for successful fertilization in the water column. Due to over harvesting and/or disease, most southern California abalone populations exist in low density aggregations of adults. That may have detrimental impacts on their reproductive success. Abalones already have reproductive strategies such as synchronized spawning and conspecific sperm chemotaxis that potentially improve fertilization success. They are also observed contracting their muscular bodies while spawning, which may be an unquantified mechanism that increases gamete dispersal distances. We studied the effects of these contractions on gamete plumes of the red abalone, Haliotis rufescens. We hypothesize that the heights of ejected gamete plumes increase with increasing contractile force. We measured the forces of adult red abalone contractions using a force transducer, recorded the heights of the resultant gamete plumes, and captured egg particles in high-speed camera frames. We found that the gamete plume heights were not correlated with contraction forces, but abalone body mass and width of the gonad were positively correlated with plume height. This supports the importance of having larger females in a population to support more successful reproduction events. This novel research will enhance our knowledge of evolved abalone behaviors and guide out-planting strategies for abalone reintroductions and restoration.

EFFECTS OF CONCRETE TILE SURFACE SHELL AND TEXTURE ON THE RECRUITMENT OF NATIVE AND NON-NATIVE OYSTERS IN SOUTHERN CALIFORNIA
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Living Shorelines slow coastal erosion by promoting the growth of native foundation species that accumulate sediment and attenuate wave action. Oysters are historically abundant animals that are
commonly targeted for Living Shorelines for their added benefit of filtering water. Concrete mixed with natural materials, such as shell, formed into a dome-shape structure with holes, called a reef ball, can be used as hard substratum to promote the growth and recruitment of oysters. We are investigating whether modifying the concrete shell composition and surface texture can preferentially recruit and promote the growth of native Olympia oysters, Ostrea lurida, and discourage the recruitment and growth of non-native Pacific oysters, Crassostrea gigas. We deployed four treatment types with surface shell (crushed and full shell) or without shell (smooth and rough concrete). The full shell and rough concrete surface had added surface texture to investigate the effect of rugosity on the recruitment of oysters. Seven replicates per treatment were deployed at two sites in San Diego Bay and one site in Newport Bay, CA, at 0 m MLLW from May to September 2018. Two-way ANOVAs tested for the effects of site and treatment on the difference in native versus non-native oyster percent cover. There was a rugosity by shell cover interaction (p<0.001) at one site in San Diego but no effect at the other sites (p>0.05). Reef ball rugosity and shell cover should be determined on a site-by-site basis to maximize native oyster success relative to non-native oysters.

IMPACTS OF *EGREGIA MENZIESII*, A FOUNDATIONAL ALGA, ON INTERTIDAL COMMUNITIES IN NORTHERN WASHINGTON STATE
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Canopy-forming seaweeds provide shade for smaller algae and invertebrates in intertidal communities, ameliorating low tide abiotic stressors such as ultraviolet radiation, desiccation, and high temperatures. Conversely, canopies can negatively affect understory organisms by limiting settlement, causing physical disruption, and trapping sand. We are examining the effect of *Egregia menziesii*, a canopy-forming foundation species, on intertidal communities, using manipulative experiments in northern Washington. We hypothesized that plots with *Egregia* would have higher abundance and richness of other invertebrates and algae than plots without *Egregia*. We have set up 25 low intertidal plots, each 0.25m^2 in size, where we randomly assigned the following five treatments (five replicates of each): Natural *Egregia* (no manipulation), –*Egregia* (*Egregia* removed), No-Natural *Egregia* (no manipulation), +*Egregia* (transplanted *Egregia*), or +mimic *Egregia* (plastic *Egregia* mimic). We have conducted community surveys of sessile and mobile organism cover/abundance for three seasons (Summer 2019, Winter 2020, and Summer 2020). We have also measured sand depth and temperature within all plots. Our data show temperature differences between plots with *Egregia* and without *Egregia*, confirming that *Egregia* can ameliorate heat stress. We predicted *Egregia* plots would trap more sand during the winter but have seen no strong evidence of sediment trapping in any treatment. We predict plots with *Egregia* will have higher richness and abundance than plots without *Egregia*. 