75th Annual Shellfish Conference and Tradeshow

Contributed Abstracts

September 20th-22nd, 2021

PCSGA

National Shellfisheries Association
Pacific Coast Section
Founded 1971

DIFFERENCES IN SPATIOTEMPORAL ENVIRONMENTAL STRESSORS ASSOCIATED WITH CLIMATE CHANGE AFFECT SHELLFISH PHYSIOLOGY

Lindsay Alma* and Jacqueline Padilla-Gamino

The urbanized estuary of Puget Sound, Washington is a highly productive ecosystem known for its profitable commercial shellfish aquaculture industry. In the past decade, however, scientists and aquaculture industry leaders have begun to observe the negative impacts of climate change in this important ecosystem. Shellfish in Puget Sound waters are already experiencing higher acidification, deoxygenation, and temperature levels than predicted by climate models for the end of the century. These co-occurring environmental stressors present a serious threat to bivalve physiological performance, their ability to calcify, and assimilate nutrients, which will pose a huge impact on the shellfish aquaculture industry. The body of literature concerning the physiological impacts of multiple climate change related stressors is rapidly increasing. Laboratory-based studies, however, lack the complexity of co-occurring drivers, which curtails our ability to realistically project future physiological responses to climate change. This research explores how environmental variability impacts *in situ* physiological performance, diet, and marketability of two ecologically and economically important bivalves, the native Olympia oyster (*Ostrea lurida*), and the non-native Mediterranean mussel (*Mytilus galloprovincialis*). To examine acclimatization and physiological responses to environmental variability, we held bivalves at either 5 or 20 meters below the water surface at 3 locations in Puget Sound and recorded oceanographic parameters for one year. Our results show that both species had greater growth rates from July-January when compared to January-July. We found significant differences in total lipid content and fatty acid saturation state suggesting differences in metabolic demand and energetic trade-offs. Biochemical analysis revealed a reorganization of signatures depending on depth and season, suggesting spatiotemporal differences in food availability and assimilation. By combining oceanographic field observations with quantitative physiological analysis, we can provide relevant and novel insights into the potential for acclimatization and the ability of bivalves to cope with environmental variation. Furthermore, our study provides crucial information to commercial shellfish growers as they develop new strategies to mitigate the negative impacts of climate change on bivalve productivity, nutritional content, and performance.

UNBLOCKING THE BOTTLENECKS IN ENDANGERED PINTO ABALONE RECOVERY

Eileen Bates*

No abstract submitted.

NEW RESEARCH ON POSSIBLE CHEMICAL CONTROLS FOR BURROWING SHRIMP- A SUMMARY OF RESULTS

David Beugli*, Jeffry Barrett, Kim Patten

No abstract submitted.

EXAMINING PARASITE DIVERSITY IN GREEN CRABS (*CARCINUS MAENAS*) IN INVASIVE WEST COAST POPULATIONS

April Blakeslee*, Daisey Newman, Chelsea Wood, Emily Grayson, P. Sean McDonald, and Mark Torchin

No abstract submitted.

ACTIVE PARTICIPATION DIVERSIFICATION DURING A CLIMATE SHOCK: A CASE STUDY OF THE 2015/16 CALIFORNIA DUNGENESS CRAB FISHERY DELAY

Kathryn Bland* and Sunny Jardine

No abstract submitted.

SHOREBIRD FORAGING IN A MOSAIC OF OYSTER CULTURE, EELGRASS AND MUDFLAT HABITATS

Fiona Boardman* and Jennifer Ruesink

Intertidal soft-sediment systems in the Pacific Northwest serve as important stopover sites and foraging grounds for a variety of shorebirds during their migrations. From spring 2020 through fall 2021, we monitored shorebird foraging in a mosaic of oyster culture, eelgrass and mudflat habitats in Grays Harbor, WA. Our study captures seasonal differences in shorebird species present, and allows us to determine how shorebirds respond to different intertidal habitat types at a small scale. Understanding seasonality and habitat-use is critical for making management decisions regarding significant stopover sites for migratory shorebirds.

CHUGACH REGIONAL OCEAN MONITORING PROGRAM: A COMPREHENSIVE MONITORING PROGRAM FOR SHELLFISH HEALTH AND SAFETY IN SOUTHCENTRAL ALASKA

Maile Branson*, Jeff Hetrick, Jacqueline Ramsay, and Willow Hetrick-Price

Paralytic shellfish toxins (PSTs) have become an increasingly severe and pervasive problem in Alaska. There is currently no state-operated biotoxin monitoring program for non-commercial shellfish in Alaska, yet many communities rely on native shellfish for both subsistence and recreational use. The Chugach Regional Resources Commission (CRRC) is a Tribal consortium representing seven Tribes in the Prince William Sound and Lower Cook Inlet regions of Alaska. CRRC operates the Alutiiq Pride Marine Institute (APMI), located in Seward. CRRC/APMI presently conducts ocean monitoring across its Tribal region through its Chugach Region Ocean Monitoring (CROM) program. The CROM program works with Tribal members in each community to conduct weekly ocean sampling. These samples are sent to APMI along with field data for analysis. At present, this program provides comprehensive monitoring for dissolved inorganic carbon, harmful phytoplankton species, and shellfish toxins. Phytoplankton abundance data are collected via phytoplankton tows, and Tribal technicians are trained in basic algal speciation techniques to provide field data. Shellfish samples are also collected and sent to APMI, where biotoxin testing is conducted using an Enzyme-

Linked Immunosorbent Assay. Weekly reports are disseminated to both Tribal members and the general public via the CRRC/APMI websites and social media outlets. Final data from the CROM program will be utilized to provide a comprehensive view of baseline oceanic conditions across the costal Gulf of Alaska. This project is working to build regional Tribal capacity through CRRC/APMI to monitor and study the precipitating factors and incidences of PSTs in native shellfish in order to support safe and sustainable harvest opportunities for both local communities and the shellfish industry in southcentral Alaska.

THE EFFECTS OF AN ASCAROPHIS NEMATODE ON *NEOTRYPAEA CALIFORNIENSIS* BURROWING BEHAVIOR

Joseph Brockman*, and Brett Dumbauld

Pacific oyster aquaculture is negatively affected by burrowing activity and bioturbation of native burrowing ghost shrimp, *Neotrypaea californiensis*. Burrowing shrimp cause the oysters to be covered by sediment and suffocate. The shellfish aquaculture industry used a chemical to control burrowing shrimp populations in Washington State coastal estuaries for about fifty years, but that practice has come under recent public scrutiny, so growers continue to seek alternative control methods. To inform potential biological control measures for burrowing shrimp, we investigated whether native nematode parasites affect distribution and abundance populations in west coast estuaries. Nematode parasites (*Ascarophis* and *Similascarophis* spp.) have been shown to infect ghost shrimp in US west coast estuaries and are hypothesized to affect shrimp burrowing in a way that increases susceptibility to predation by potential fish hosts. In this study we investigated the differences in *Ascarophis* nematode prevalence in ghost shrimp populations between sites with higher densities of sturgeon feeding pits in Willapa Bay, Washington. Additionally, we plan to conduct a laboratory experiment to further investigate differences between the burrowing behaviors of infected and non-infected shrimp. Study results are expected to increase understanding of the factors controlling ghost shrimp populations and might inform the development of future control methods for shellfish aquaculture.

CALCULATING ECOSYSTEM SERVICES FOR MARKETS AND MITIGATION

Amanda Carr*

No abstract submitted.

SEAWEED FARMING & MARINE RENEWABLE ENERGY: PARALLELS AND OPPORTUNITIES FOR INTEGRATION

Meg Chadsey*; Molly Grear, Simon Geerlofs, Scott Edmundson, Tom Mumford, and Tiffany Stephens

Seaweed farming and marine renewable energy (MRE) have a surprising amount in common: social license challenges, seaweed-based biofuels, and opportunities for integration (e.g. wave-powered remote sensors for open-water kelp farms). Both

industries are gaining traction in the Pacific Northwest—is there potential for practitioners from both communities to learn from and leverage each other's work?

SHELL BORING POLYCHAETES IN THE PACIFIC NORTHWEST: POLICY, ENGAGEMENT, AND MANAGEMENT IMPLICATIONS

Megan Considine*, Julieta C. Martinelli, Teri L. King, Lorenz Hauser, Jaqueline L. Padilla-Gamiño, Steven S. Rumrill, and Chelsea L. Wood

Shell boring polychaetes, also known as mud blister worms, bore into the shells of commercially important shellfish species, which can render shellfish products unmarketable due to a reduction in aesthetic quality and host fitness. This product devaluation is especially true for the lucrative half-shell market where shellfish are presented to consumers with the meat lying in the cupped valve. Recently there has been an uptick in mud blister worm infestations on commercial oyster farms in the Pacific Northwest, the leading bivalve producer in the United States. This talk will discuss the research implications of a recent initiative to (1) quantify the current distribution of shell boring polychaetes on oyster farms and (2) identify treatments to reduce transmission and mitigate impacts. In particular this talk will focus on connections of this research to various stakeholder groups including industry, consumers, resource managers, and policy makers.

WASHINGTON LAND USE, LEASING AND REAL ESTATE CONSIDERATIONS IN SHELLFISH FARMING

Jesse DeNike*

In addition to federal and state permitting, shellfish farmers in Washington State must comply with local land use regulations addressing environmental, use conflict, and aesthetic concerns. Farmers must also navigate numerous real estate issues, which may include leasing from private or public property owners and resolving boundary line questions or disputes. Many of these issues are becoming more complex or contentious given increasing development pressure in rural areas and the potential for sea rise. This presentation will discuss these evolving areas of the law and provide information for consideration in managing existing, or establishing new, shellfish farms.

MARKER-ASSISTED SELECTION FOR OSHV-1 TOLERANCE IN A PACIFIC OYSTER BREEDING PROGRAM

Konstantin Divilov*, Noah Merz, Blaine Schoolfield, Tim Green, and Chris Langdon

OsHV-1 (oyster herpesvirus) currently causes mass mortalities in Pacific oysters in Tomales Bay, California, and a virulent microvariant of this virus has recently been detected in San Diego Bay. Selective breeding of oysters for disease tolerance is one of the best mitigation strategies available for reducing the impact of OsHV-1 once it has become established in a bay. Selective breeding conducted by the Molluscan Broodstock Program (MBP), a Pacific oyster breeding program at the Hatfield Marine Science Center (Newport, OR, USA), has increased the likelihood of survival to OsHV-1 (Tomales Bay OsHV-1 variant) in the MBP oyster breeding population by 21 percentage

points. In addition to the need to further increase survival to OsHV-1 in Tomales Bay, it remains to be seen if tolerance to the Tomales Bay OsHV-1 variant provides tolerance to OsHV-1 microvariants. Analyzing ~100,000 genome-wide molecular markers in three cohorts of oysters evaluated in Tomales Bay, we found a genomic region on chromosome 8 that was significantly associated with OsHV-1 tolerance. Furthermore, we found that this region is significantly positively correlated with the gene expression levels of two viral innate immunity genes in spat, which suggests that this region will likely provide tolerance to OsHV-1 microvariants due to a heightened viral innate immune system in oysters carrying the genomic variation present in this region. In the latest MBP cohort, this region was selected using marker-assisted selection and will likely result in an even greater increase in survival to OsHV-1 in the MBP breeding population compared to the previously successful pedigree selection method.

A COMPARISON OF JUVENILE DUNGENESS CRAB HABITAT PROVIDED BY CONTEMPORARY OYSTER AQUACULTURE VS. HISTORICAL NATIVE OYSTERS IN WILLAPA BAY, WA

Brett Dumbauld*, Jessica Murphy, Lee McCoy, Nathaniel Lewis

Oysters and seagrasses provide structurally complex estuarine habitat for fish and invertebrate species. On the U.S. West Coast, complex oyster habitat was historically provided by the native Olympia oyster Ostrea lurida but is now provided by the commercially cultured oyster *Crassostrea gigas*. Ostrea lurida is found in subtidal and low intertidal areas, whereas *C. gigas* is predominantly cultured at higher intertidal elevations, resulting in a potential shift in available habitat for other fish and invertebrates that use this intertidal habitat. This change in the available habitat and its use was examined for the juvenile Dungeness crab *Metacarcinus magister*, and results showed the following: (1) comparable crab densities in remnant and restored populations of *O. lurida* and cultured *C. gigas* in two estuaries, (2) generally higher crab densities in both of these shell habitats than those observed in eelgrass Zostera marina or open mud habitat, (3) contemporary juvenile crab density in intertidal areas of Willapa Bay was most influenced by distance from the estuary mouth (declining with increasing distance) but also declined with increasing tidal elevation, and (4) when extrapolated to the estuarine ecosystem scale using areal estimates of habitat coverage, historical habitat provided by *O. lurida* potentially produced three times more juvenile crabs than those currently produced in cultured *C. gigas*. Nonetheless, both intertidal oyster habitats contribute more to juvenile crab production than eelgrass or open unstructured mud, and the ecosystem services associated with the placement of native and commercial oyster beds should be considered when defining goals for and permitting both aquaculture and native oyster restoration in Willapa Bay and other U.S. West Coast estuaries. Managers should consider this shifting temporal baseline in intertidal habitat provision, but also conducting similar evaluations at this broader estuary scale when evaluating habitat value for other resources that use these habitats differently.

WHAT LIMITS BURROWING SHRIMP RECRUITMENT AND JUVENILE SURVIVAL?

Brett Dumbauld*, Brooke McIntyre, Nate Lewis, and Joe Brockman

The ghost shrimp, *Neotrypaea californiensis*, is an important member of estuarine intertidal communities along the US Pacific Coast, but its burrowing behavior causes significant problems for shellfish culture. We have monitored populations of these shrimp in Willapa Bay, Washington for three decades and in Yaquina Bay, Oregon since 2005. Ghost shrimp density increased dramatically in the 1990's in Willapa Bay, declined almost as precipitously through 2010, and has since increased again. Similar though less dramatic population fluctuations have occurred in Yaquina Bay since 2005. These shrimp have pelagic larvae which develop in the coastal ocean and then "recruit" back to estuaries, and we have previously documented significant relationships between the number of recruits and the number of larger 1 year-old shrimp present a year later in both estuaries. Recruitment events since 2010 have resulted in the recent population increases in both of these estuaries which are of concern to shellfish growers, especially in Willapa Bay where a control program was recently suspended. Here, we update this long-term record of shrimp recruitment, discuss some potential mechanisms that might influence juvenile shrimp survival and present some observations on recent dramatic population losses that have been observed at several discrete locations in Willapa Bay.

WEST COAST SENTINEL MONITORING PROGRAM: 2021 UPDATES FROM THE FIELD

Ford Evans*, Blaine Schoolfield, William Schoeneck, Konstantin Divilov, Chris Langdon, Brett Dumbauld, Brooke McIntyre, Colleen Burge, and Sukanya Dayal.

Ostreid herpesvirus 1 (OsHV-1) has significantly impacted Pacific oyster (*Crassostrea gigas*) production globally. Within the US, OsHV-1 was first detected in 2002 in Tomales Bay, California, and has subsequently been found in neighboring Drakes Bay and Bodega Bay. In 2018, a microvariant of OsHV-1 was detected in San Diego Bay, California. Recognizing the risk of regional spread and the commercial impact of the OsHV-1 herpes virus, a multi-state oyster sentinel program, with strong industry collaboration, was initiated in 2020 to monitor the prevalence and pathogenesis of this virus in juvenile Pacific oysters planted at commercial growing grounds in California, Oregon, and Washington. In Spring 2020, two sentinel families were created. The first was a hybrid cross ("YxP") previously shown to be susceptible to OsHV-1. The second family was a cross anticipated to be high-yielding and demonstrate above average tolerance to OsHV-1 based on pedigree data ("29.001"). Spat were planted out by industry partners in San Diego Bay (CA), Tomales Bay (CA), Tillamook Bay (OR), Willapa Bay (WA), and Totten Inlet (WA). Industry partners counted spat every two weeks and sent samples to us for analyses, including OsHV-1 presence and viral load. In 2020 sentinel spat at sites in Oregon and Washington demonstrated high survival and tested negative for OsHV-1. Sentinel spat from both crosses planted in San Diego Bay experienced nearly 100% mortality over a four-week period and tested positive for the OsHV-1 San Diego µvar. In Tomales Bay during the 2020 field season, each replicate bag typically displayed a single viral load peak. The magnitude of the peak within each replicate bag was correlated with both overall survival at the end of the field season and average shell length at the time of peak viral load. Genotype also affected overall survival, with 29.001 (bred for high survival in Tomales Bay) showing

greater tolerance to OsHV-1 compared to the YxP hybrid (non-selected control cross). In 2021, two families were again created (tolerant 30.001 and susceptible YxP) and planted at the same five sites as in 2020. Differences between the 2020 and 2021 field seasons will be discussed.

A COLLABORATIVE, MULTI-FARM APPROACH TO BUILDING NATIVE OLYMPIA OYSTER AQUACULTURE FOR MARKET AND RESTORATION ON TOMALES BAY, CA.

Gary Fleener*

No Abstract submitted.

THE USE OF GENOMIC TOOLS TO INFORM OLYMPIA OYSTER RESTORATION IN WASHINGTON

Mackenzie Gavery*, Ryan Crim, Crystal Simchick, Jodie Toft, and Rick Goetz

Olympia oysters (*Ostrea lurida*) are the only oyster native to the west coast of the United States and were once abundant in Puget Sound. Intense commercial harvests, habitat loss, and pollution led to collapse of the fishery by 1930. While small remnant populations have persisted in many areas across their historic range, dense core aggregations are extremely rare and thus the focus of several restoration programs across the West Coast. Puget Sound Restoration Fund (PSRF), in collaboration with NOAA and the Washington Department of Fish and Wildlife, produces hatchery-bred juvenile Olympia oyster seed at the Kenneth K. Chew Center for Shellfish Research and Restoration. Juvenile Olympia oyster seed have been out-planted to a number of sites in Puget Sound for restoration. A primary goal of the shellfish recovery effort is to have minimal negative impacts on existing wild stocks. While hatchery protocols are carefully designed and implemented with the goal of producing seed that mimic the genetic structure of local wild populations, characterizing the genetic makeup of out-planted individuals in relation to local wild populations is extremely important to determine potential impacts on the genetics of the recovering populations. To address this, we are using high-throughput sequencing (RAD-Seq) to produce thousands of genetic markers (single nucleotide polymorphisms (SNPs)) for 3 Olympia oyster populations and their hatchery-reared progeny. Preliminary results, including the development and analysis of SNPs to evaluate various genetic diversity metrics in out-planted seed, will be presented.

THE CONTRIBUTION OF SUMMER HEATWAVES TO ‘TRIPLOID MORTALITY’ OBSERVED DURING COMMERCIAL PACIFIC OYSTER PRODUCTION IN WASHINGTON STATE

Matthew N. George, Olivia Cattau, MacKenzie Gavery, Brent Vadopalas, and Steven Roberts

Pacific oysters (*Crassostrea gigas*) are an important global aquaculture species, accounting for the majority of hatchery-reared and farmed shellfish in Washington State. Domestic oyster production was accelerated in the 1980’s after the creation and

adoption of hatchery techniques that induce triploidy, resulting in the production of oyster seed with an extra chromosome set. When compared to diploids (2n), triploid oysters (3n) typically display reproductive impairment, allowing for shifts in energy allocation that enable faster growth and year-round marketability by avoiding the harvest of 'spawny' oysters during summer months. While the enhanced marketability of triploid oysters is irrefutable, increasingly frequent reports from both international and domestic shellfish farmers suggest that triploid oysters can experience reduced survivorship ('triploid mortality') with respect to diploids growing at the same grow-out site. To investigate the potential cause(s) of reduced survivorship across ploidy, we employed a series of laboratory experiments that compared the physiological and transcriptional response of diploid and triploid pacific oysters to simulated heatwaves (akin to the one experienced by intertidal organisms during the summer heatwave of 2021), wherein animals were acclimated to elevated seawater temperature (30°C) and/or subjected to desiccation stress (aerial exposure for 4h at 44°C). Significant differences were observed in the metabolic rate, feeding behavior, and gene expression of diploid and triploid oysters following exposure to elevated temperature and desiccation stress in succession, resulting in significantly higher rates of triploid mortality when compared with diploids. However, exposure to elevated seawater temperatures alone was not sufficient to illicit mass die-offs in either ploidy, suggesting that if environmental factors contribute to 'triploid mortality' events observed in oyster aquaculture, exposure to multiple stressors in combination is likely required.

RAINFALL CLOSURES & ALASKA'S FIRST CONDITIONALLY APPROVED SHELLFISH HARVEST AREA

Bobbi Hudson*, Andy Suhrbier, John Kiser, and Kimberly Striker

No abstract submitted.

ASSESSMENT OF ECOLOGICAL FUNCTION & INTERACTIONS OF OYSTER CULTURE & EELGRASS

Bobbi Hudson*, Katie Houle, Jennifer Ruesink, Fiona Boardman, Brett Dumbauld, Phil Bloch, Sarah Lummis, and Kristy Kroeker

No abstract submitted.

EXAMINING THE INFLUENCE OF BURROWING SHRIMP ON NATIVE EELGRASS TRANSPLANT SUCCESS IN WILLAPA BAY WASHINGTON

Wesley Hull*

Both burrowing shrimp and seagrass are important ecosystem engineers in soft sediment environments. While there are many studies examining the interactions between these species through out the global no generalities have emerged regarding the winner of these interactions, making it difficult to predict the which species is likely to dominate in systems where they are both present. In Willapa Bay Washington, both species create habitat mosaics, but the outcomes of their interactions are unknown. To determine how burrowing shrimp and eelgrass interact with one another in Willapa Bay,

we transplanted varying densities and patch sizes of native eelgrass (*Zostera marina*) into shrimp dominated sediment.

SUSCEPTIBILITY OF SHELLFISH AQUACULTURE SPECIES IN THE CHESAPEAKE BAY AND MARYLAND COASTAL BAYS TO THE OSTREID HERPESVIRUS (OSHV-1)

Mariah Kachmar* and Colleen Burge

The Ostreid herpesvirus 1(OsHV-1) and its microvariants are highly virulent pathogens that cause mass mortalities of oysters and pose a threat to the shellfish aquaculture industry globally. OsHV-1 causes economically devastating mass mortality events up to 100% in the Pacific oyster (*Crassostrea gigas*). However, OsHV-1 and its variants lack host specificity and are known to infect a range of bivalve species and be carried by the European green crab (*Carcinus maenas*). There is a lack of testing and research on the East coast of the United States, including in the Chesapeake and Maryland Coastal Bays where aquaculture is an important industry for food production and restoration efforts. Chesapeake and Maryland coastal bay species are already threatened by various parasitic and viral diseases, indicating that they may be vulnerable to OsHV-1. A recent laboratory study indicates that the eastern oyster (*Crassostrea virginica*) can experience infection and mortality from OsHV-1. Therefore, determining the susceptibility of economically and ecologically important Maryland species to OsHV-1 is an essential step in improving biosecurity and disease management to protect the sustainability of the aquaculture industry.

THE PRACTICAL VALUE OF eDNA INFORMATION: A CASE STUDY OF EUROPEAN GREEN CRAB

Abigail Keller*, Ana Ramon-Laca, Emily Grason, Sean McDonald, and Ryan Kelly

Advances in environmental DNA (eDNA) applications hold promise for revolutionizing environmental monitoring and management, providing increased detection sensitivity at reduced cost and survey effort. However, implementation of eDNA methods in decision-making contexts lags significantly behind technical progress in research because of uncertainty in data interpretation and a lack of standard operating procedures for how to best integrate eDNA approaches into existing management efforts. We address these key challenges by developing a Bayesian model that uses heterogeneity in molecular detection probability to interpret patterns of eDNA signals, integrating information from both traditional and eDNA monitoring methods to jointly inform local species density. Critically, the model offers a framework for quantifying the marginal benefit of eDNA data, specifically how the addition of eDNA data improves the precision and accuracy of species density estimates. We illustrate the approach using environmental DNA information from a marine invasive species, *Carcinus maenas*, across Washington state, USA. Importantly, we document *C. maenas* eDNA beyond the previously known invasion front and find exponential increases in the marginal benefit of environmental DNA data at these locations. In addition, our model quantifies uncertainty surrounding estimates of species density and provides the necessary interface for combining molecular and traditional data streams. These results provide managers the information and tools needed to successfully integrate environmental DNA information into

management decisions and suggest that eDNA approaches are best suited for mapping invasion fronts and locations with low species density.

GOT WORMS? MUD WORM SHELL IDENTIFICATION

Teri King*, Julieta Martinelli*, and Chelsea Wood*

No abstract submitted.

HOW TO MAKE YOUR LIFE EASIER DURING A DISASTER OR MORTALITY EVENT: FARM INVENTORY AND REFERENCE SAMPLE TECHNIQUES

Teri King*

No abstract submitted.

HIDING IN PLAIN SIGHT: SHELLFISH KILLING PHYTOPLANKTON IN WASHINGTON STATE

Teri L. King*, Nancy Nguyen, Gregory J. Doucette, Zhihong Wang, Brian D. Bill, Melissa B. Peacock, Shelbi L. Madera, Ralph A. Elston, and Vera L. Trainer

No abstract submitted.

AN UNTAPPED ECOSYSTEM SERVICE: THE PATHOGEN FILTRATION CAPABILITY OF EELGRASS (*ZOSTERA MARINA*)

Corinne Klohmann* and Jacqueline Padilla-Gamiño

Eelgrass (*Zostera marina*) is a marine angiosperm found in coastal temperate waters worldwide. Eelgrass is a vital part of coastal ecosystems providing nurseries for fish, habitat for invertebrates, sediment stabilization, coastal protection, water filtration, and carbon sequestration. In the tropics, seagrass beds have demonstrated their ability to decrease the abundance of the bacterial pathogen Enterococcus. Enterococcus-associated pathogens can sicken humans and other animals in the water. This study will address temperate seagrass pathogen filtration and examine pathogen filtration under changing ocean conditions. Using field data and laboratory experiments I will test the pathogen filtration capability of *Z. marina* in the coastal waters of Puget Sound. Additionally, I will assess the impact of light, dissolved oxygen, temperature, and pH on the potential filtration service in order to determine the underlying mechanisms involved in the reduction of pathogens. This research has large implications for aquaculture, fisheries, conservation, and human health and is particularly relevant in Puget Sound, as there have recently been two large sewage spills here. Furthermore, given the global distribution of eelgrass, this research has direct applications to human and ecosystem health worldwide.

UPDATE ON NOAA/PSMFC-FUNDED WEST COAST OYSTER CONSORTIUM - PREPARING FOR FUTURE CHALLENGES OF OCEAN ACIDIFICATION, VIBRIO CORALLIILYTICUS AND OSHV-1 MICROVARIANTS

Chris Langdon*, Konstantin Divilov, Mary Arkoosh, Joseph Dietrich, Brett Dumbauld, Lionel Degremont, Chris Eardley, Tim Green, and Maria Haws
The Pacific States Marine Fisheries Commission (PSMFC) and NOAA have funded a US West coast consortium of scientists and regulators to help prepare the oyster industry for likely future threats due to global warming, ocean acidification and associated diseases. The consortium works in concert with the USDA/ARS shellfish ecology and genetics program and the Molluscan Broodstock Program based at the Hatfield Marine Science Center, Newport, Oregon. The first objective is to improve the hatchery performance of larvae by improving their resistance to ocean acidification conditions and associated outbreaks of the pathogen Vibrio coralliilyticus. Secondly, to improve Pacific oyster diploid and polyploid broodstock through selection for improved survival against OsHV-1 in both field and lab trials, as well as through the development of genetic markers that will identify individual broodstock oysters with potential resistance to OsHV-1. Lastly, the consortium will develop a comprehensive strategy for regulators, agencies, researchers and industry members to prevent the introduction and spread of OsHV-1 microvariants on the US West coast. This presentation will provide an update on progress since the inception of the project in fall 2019.

TRANSFORMING ALASKA NATIVE SEAWEED TRADITIONS INTO A NEW REGENERATIVE ECONOMY
Dune Lankard*
This session will showcase leaders in the Blue Economy – Alaska Natives staking a claim in the state's plans to grow a billion-dollar mariculture industry. While leading fisheries are lining up for permits, the difference lies in millennia of experience in sustainable harvest and marine responsibility that inform a Native brand in indigenous-led kelp farming and processed foods.

THE LATEST IN SHELLFISH FARMING IN HAWAII
Amanda R.K. Lowrey*
This presentation will provide an update on the Hawaii shellfish program.

PREVALENCE AND DISTRIBUTION OF SHELL-BORING POLYCHAETES (POLYDORA SPP.) IN OYSTER FARMS FROM CALIFORNIA TO ALASKA
Julieta C. Martinelli*, Helen R. Casendino, Megan E. Considine, Carolyn Tarpey, Teri L. King, Lorenz HAUSER, Jaqueline L. Padilla-Gamiño, Steven S. Rumrill, and Chelsea L. Wood
The west coast of the US is the leading producer of aquaculture oysters in the country, making it urgent to understand recently reported cases of oysters infested with shell-boring worms. Marine polychaetes in the genus Polydora (and a few other, related genera) can burrow into the shells of commercially important bivalves, creating mud blisters. Because they are unappealing to consumers and can burst, fouling oyster flesh, these blisters are an economic burden on oyster half-shell industries. To understand the extent of this problem and obtain information that can lead to solutions, we collected over 3,000 oysters from 35 farms in four states (CA, OR, WA and AK). We

determined infection prevalence for each site, state, and growth method (on vs off bottom) across two years, spanning four sampling seasons. Prevalence per state ranged from 13 to 37%. Polychaetes were extracted from infected shells from all states for molecular analyses. We used mitochondrial (cytochrome c oxidase 1, CO1) and nuclear (18S rRNA) genes for species-level identification. Genetic markers confirmed the presence of P. websteri at more than one site in the west coast. Findings from this study will be the foundation for advising the US west coast shellfish industry on the progress of the Polydora invasion and strategies for reducing the economic impacts of these globally-distributed polychaetes.

TESTING EFFECTIVE TREATMENTS TO CONTROL INFECTIONS BY SHELL-BORING POLYCHAETES (POLYDORA SPP.) IN THE US PACIFIC NORTHWEST

Julieta C. Martinelli*, Helen R. Casendino, Laura H. Spencer, Lindsay Alma, Teri L. King, Jaqueline L. Padilla-Gamiño PADILLA-GAMIÑO, and Chelsea L. Wood

Shell-boring worms in the genus Polydora are well-known for making unsightly burrows and mud blisters in the shells of their hosts. These marine polychaetes frequently parasitize commercially important bivalves such as Pacific oysters (*Crassostrea gigas*), creating challenges for the oyster half-shell industry as the parasite leads to loss of product value. Given that one of the main difficulties faced by oyster growers is controlling this pest, we consulted shellfish growers from Washington State to create treatments that are both effective and easy to apply on farms. We tested four treatments in two experiments carried out with diploid Pacific oysters infected with Polydora spp. from Washington State. Our experimental design consisted of three stages: (1) the main experiment to test treatments, (2) a shorter growth-assessment experiment, (3) and oyster respirometry trials. During Fall 2020 and Spring 2021 we subjected over 675 oysters to four different treatments: ‘Dry’, ‘Freshwater’, ‘Fresh-Dry’, ‘Refrigeration’ and a Control. None of these treatments resulted in oyster mortality and the ‘Dry’ and ‘Fresh-Dry’ treatments were 100% effective at killing shell-boring worms. The ‘Refrigeration’ treatment was also highly effective but some worms were found alive. The growth assessment indicated that none of the treatments disproportionately affected oyster growth over three months, and the respirometry trials showed no significant differences in oxygen consumption in oysters from different treatment groups. These experimental results provide cost-effective solutions that can be scaled up for shellfish farms throughout the US Pacific Northwest and other regions to help control and mitigate shell-boring worm infections.

UPDATE ON COASTAL GREEN CRAB MANAGEMENT: MONITORING, RESEARCH AND CONTROL EFFORTS

P. Sean McDonald*, Alexandra Stote, Emily Grason, Kate Litle, Jeff Adams, and Amy Iinhart

Though European green crab, *Carcinus maenas*, has been periodically abundant in coastal embayments of Washington State since the late 1990’s, the last decade has seen dramatic increases in abundance within Willapa Bay and Grays Harbor, as well as range expansion into Washington’s Salish Sea. These developments have the potential for more destructive impacts and dynamics. Within Washington waters of the Salish

Sea, green crab spread is tracked by a citizen science network of early detection sites by Washington Sea Grant (WSG) Crab Team. Crab Team's network monitors more than 50 sites across Puget Sound, the San Juan Islands and the Strait of Juan de Fuca, with the goals of assessing green crab status and impacts. Despite limitations imposed by health restrictions for COVID-19, Crab Team has expanded efforts to the coastal estuaries by working closely with Washington Department of Fish and Wildlife, regional and local agencies, Tribes, and industry partners to enact monitoring and control efforts. The present presentation provides an overview of ongoing work. A collaborative, coordinated and rapid response is required to offer the greatest chance for successful protection of natural, economic, and cultural resources.

MITIGATING THE EFFECTS OF MULTIPLE STRESSORS IN PACIFIC OYSTERS: COMPARISON OF DIPLOID AND TRIPLOID *CRASSOSTREA GIGAS*

Jacqueline Padilla-Gamiño*, John Davis, Paul McElhany, Shallin Busch

Ocean warming, acidification, and hypoxia are increasing threats in the world's coastal waters, with potentially severe consequences for marine organisms and ocean economies. Among these threats is whether currently farmed species will possess the capacity to adapt or acclimatize to climate change and remain profitable in the future. In this context, the number of chromosome copies (ploidy) can be an important determinant of a variety's economic success. Deciding which varieties to produce is a critical question facing growers who must consider complex trade-offs in a changing, multi-stressor environment. University of Washington, NOAA and Baywater Shellfish will collaborate to integrate oceanographic measurements, field work, and laboratory experiments to examine the physiological tolerance and survival of diploid and triploid oysters under multiple stressors. When combined with economic information and summarized in a decision support tool, our results will help shellfish growers balance the risks and benefits of planting triploid oysters (that are marketable in summer) against the potentially higher mortality of triploids compared to diploids as a function of the multi-stressor environment.

FEDERAL AND WASHINGTON STATE PERMITTING AND REGULATORY UPDATE

Samuel W. (Billy) Plauché*

Federal and Washington State Permitting and Regulatory Update

KELP AND CLIMATE CHANGE: A META-ANALYSIS AND FIELD STUDY

Miranda Roethler* and Jacqueline Padilla-Gamiño

Ocean acidification (OA) and warming (OW) are growing problems for fisheries and aquaculture, both in the Pacific Northwest and around the world. There is growing interest in establishing a macroalgae aquaculture industry in the Pacific Northwest, as well as using macroalgae to buffer oyster farms from low-pH waters. However, determining the feasibility of these ventures necessitates a comprehensive understanding of how macroalgae will fare in future oceans. In general, kelps are highly vulnerable to OW, and have mixed reactions (often life-stage and species-specific) to

OA. Unfortunately, very little experimental work has been conducted on algae in the Pacific Northwest, despite our high species richness and evidence that bull kelp (*Nereocystis luetkeana*) cover has declined substantially in the last 100 years. In an attempt to answer the question “how will kelp in the Pacific Northwest respond to climate change?” we first conducted a comprehensive literature review and meta-analysis of the effects of OA and OW on kelp (order Laminariales). We also conducted a laboratory experiment to determine how *N. luetkeana*, the dominant canopy-forming kelp species in Puget Sound, responds to OA and OW. We exposed macroscopic sporophyte fronds and microscopic gametophytes to several temperature and pCO2 levels and measured growth, development, and photosynthesis. Results from the meta-analysis and laboratory experiment are complimentary; the meta-analysis provides us with current gaps in the literature, and the laboratory experiment allows us to compare Puget Sound populations to global trends.

LIMB LOSS AS AN INDICATOR OF BIOTIC RESISTANCE AGAINST THE NON-NATIVE EUROPEAN GREEN CRAB (*CARCINUS MAENAS*) IN COOS BAY, OREGON

Kim Sims*

The presence of predators and competitors can offer biotic resistance against the establishment of non-native species, including the European green crab, *Carcinus maenas*, (EGC) in the estuary of Coos Bay, Oregon. It has been suggested that limb loss, or autotomy of the EGC will increase in areas that include populations of larger native crabs such as the red rock crab, (*Cancer productus*) and Dungeness crab (*Metacarcinus magister*). To test this hypothesis, we analyzed data from a long-term monitoring program collected by researchers from Oregon State University and South Slough National Estuarine Research Reserve (SSNERR). From this data set we examine the patterns of limb loss as functions of size and location and extract indicators of the relative population density of EGC and other native crab species.

AQUACULTURE IN THE SANTA BARBARA CHANNEL: THE NEXT STEPS

Brian Pendleton*, Robert Smith, Laurie Monarres, and Ev Ashworth

Over the past six years, the Ventura Port District and its partners have sought to establish the Ventura Shellfish Enterprise project, a new offshore shellfish farm in federal waters. During that time, in collaboration with NOAA and other regulatory agencies, a number of tools have been developed which can assist private companies that may want to establish a farm in the Santa Barbara Channel, or elsewhere in California. This presentation will discuss the lessons learned during that process as the Port engaged in outreach with key stakeholders, like commercial fishing interests and environmental NGOs, and addressed concerns raised by regulatory agencies. It will also highlight several of the tools and analyses developed that can assist private shellfish companies.

TRANSCRIPTIONAL RESPONSE OF PARENTAL LOW PH EXPOSURE ACROSS POPULATIONS AND GENERATIONS OF THE OLYMPIA OYSTER (*OSTREA LURIDA*)

Laura H Spencer*, Katherine Silliman, and Steven B Roberts
Ocean acidification and ocean warming potentially threaten marine calcifiers and ectotherms, particularly those which are struggling to rebound after population crashes, such as the Olympia oyster. An organism's genotype, complete environmental history, and the timing and magnitude of environmental perturbations may all determine its fitness in future ocean conditions. To begin teasing apart these complex factors, this study leveraged adult oysters with unique ancestries but known, shared histories, and assessed their transcriptional response to acidification within and across generations. We exposed three populations of adult hatchery-reared *O. lurida* to acidified conditions for 52 days, and observed varying transcriptomic responses that are indicative of previously observed, unique physiotypes. The population with the slowest growth rate, Dabob Bay, mounted the largest transcriptomic response to high pCO2. The population that is highly fecund did not respond to high pCO2 at the transcript level. Fidalgo Bay, which is moderately fecund and has a relatively high growth rate responded moderately to acidification. These three unique responses illustrate the diversity of physiological strategies in *O. lurida* that balance the energetic demands of growth, reproduction, and cellular maintenance differently to accommodate their distinct environment-of-origin. The size and whole-body transcriptomes of pooled larval offspring were assessed for signals of parental treatment and population-of-origin. Parental exposure to warming and acidification as sole exposures resulted in larger larvae, and while there was no significant interaction between the two treatments the largest larvae were produced by adults exposed to combined stressors. Population-of-origin was a dominant factor predicting larval gene expression, with only minor expression differences among larval groups with intergenerational exposures. The distinct expression patterns among populations at the adult and larval stage highlight the influence of genotype on the physiology of *O. lurida* at every stage of life. We include a review the body of literature examining phenotypic differences in the three focal Puget Sound populations of *O. lurida* as they relate to abiotic stress response.

EXPLORATION OF NEARSHORE OXYGEN DYNAMICS THROUGH COLLABORATION WITH THE OREGON DUNGENESS CRAB FISHING FLEET

Linus Stoltz* and Francis Chan
https://fishresearch.net/

ASSESSMENT OF BURROWING SHRIMP DENSITIES ON SHELLFISH AQUACULTURE BEDS IN GRAYS HARBOR AND WILLAPA BAY BY HAND-CORING TECHNIQUE

Elena Subbotin*, Jennifer Ruesink, Haleh Mawson, and Wesley Hull
Integrated pest management plans for burrowing shrimp (*Neotrypaea californiensis* and *Upogebia pugettensis*) begin with detecting pest numbers to measure an appropriate response to the problem. This study implements a manual coring method, developed by the Department of Natural Resources, on a variety of aquaculture beds in the Willapa Bay and Grays Harbor area. We analyzed seasonal variation in shrimp abundance, necessary sample sizes, the relationship between burrows and shrimp abundance, and sediment conditions. In terms of how many samples are necessary and where on the

bed to collect, both choices are influenced by density gradients on the bed. One strategy is to spread out samples (i.e. 5-pace intervals) in spots on the bed where a surface assessment suggests there might be the highest shrimp density. Growers would be able to use 3 samples on a bed and not be far off from the overall density estimate. The comparison of abundance and burrows in our samples shows that a given number of shrimp can be associated with a range of different hole counts. The majority of sites had less than 10 shrimp per sample (160 shrimp m-2 using the multiplier) and anywhere from 0-36 burrows per 0.25 m2. Sediment properties varied substantially across shellfish beds for reasons other than how many shrimp were present. However, there was a significant negative relationship between shrimp abundance and sediment organic material within sites, suggesting that the density of burrowing shrimp can affect some sediment properties. We concluded that this coring technique was feasible in terms of labor and time commitment and should benefit decision-making by providing a number representing the degree of a shrimp problem on a shellfish bed that cannot be confused with clams or worms.

GENOMIC INSIGHTS INTO EUROPEAN GREEN CRAB SPREAD AND DISPERSAL IN THE NORTHEAST PACIFIC

Carolyn K. Tepolt*, Emily W. Grason, Jeff Adams, P. Sean McDonald, and Thomas W. Therriault

The European green crab (*Carcinus maenas*) is a high-profile invasive species which has had substantial negative impacts on shellfisheries and native ecosystems where it has become established. Green crabs are a relatively recent arrival to the northeast Pacific, and have spread from central California to northern Vancouver Island in the 32 years since their detection. In the Pacific Northwest green crab populations were confined to the outer coast until 2012, when an isolated population was first reported from Sooke Basin in southern Vancouver Island. In 2016, proactive monitoring detected green crabs in Washington State's inland waters, and since then the species has undergone rapid range expansion in the northeast Pacific, with new crab detections in multiple sites across the Salish Sea and as far north as Haida Gwaii. Using high-throughput genotyping at thousands of loci, we have been characterizing the population genetic structure of green crabs in the northeast Pacific both before and during these recent expansions. Initial genomic work found that dispersal is high between most sites colonized before 2016, with the exception of a few oceanographically isolated sites which likely receive few or no larvae from other areas and are largely self-recruiting. This isolation has led to distinctive genetic signatures due to a loss of genetic diversity relative to the rest of the northeast Pacific. One such site is Sooke Basin: while Sooke is isolated from outside larvae, it does export larvae to areas as far as 400 km down the coast. This signature in Sooke allows genomic assignment of newly-detected crabs to a source either in Sooke Basin (by far the closest well-established population to the new detections) or the outer coast. Here, we will present genomic data from ~5,000 transcriptome-derived SNPs to explore the likely sources of most of the new green crab detections in the Salish Sea and other recent expansions. These data demonstrate extensive dispersal both into and out of the Salish Sea and show that dispersal in the Salish Sea appears to be complex, with multiple sources and recent introgression.

These genomic data give us a better understanding of where the first green crabs in these areas are coming from, information that is crucial to making informed management decisions to predict, prevent, and manage green crabs in the northeast Pacific.

EARLY RESEARCH AT THE USDA PACIFIC SHELLFISH BREEDING CENTER
Neil Thompson*
No abstract submitted.

WHAT'S IN THE WATER? 'OMICS ANALYSIS OF A HATCHERY MICROBIOME
Emma Timmins-Schiffman*, Samuel White, Rhonda Elliott Thompson, Brent Vadopalas, Benoit Eudeline, Brook Nunn, and Steven Roberts
Microbial communities are ubiquitous throughout ecosystems and are commensal with hosts across taxonomic boundaries. Environmental and species-specific microbiomes are instrumental in maintaining ecosystem and host health, respectively. The introduction of pathogenic microbes that shift microbiome community structure can lead to illness and death. Understanding the dynamics of microbiomes across a diversity of environments and hosts will help us to better understand which taxa forecast survival and which forecast mortality events. We characterized the bacterial community microbiome in the water of a commercial shellfish hatchery in Washington state, where the hatchery has been plagued by recurring and unexplained larval mortality events. By applying the complementary methods of metagenomics (bacterial community DNA) and metaproteomics (bacterial community proteins) we were able to more fully characterize the bacterial taxa in the hatchery at high (pH 8.2) and low (pH 7.1) pH that were metabolically active versus present but not contributing metabolically. There were shifts in the taxonomy and functional profile of the microbiome between pH and over time. Based on detected metagenomic reads and metaproteomic peptide spectral matches, some taxa were more metabolically active than expected based on presence alone (Deltaproteobacteria, Alphaproteobacteria) and some were less metabolically active than expected (e.g., Betaproteobacteria, Cytophagia). There was little correlation between potential and realized metabolic function based on Gene Ontology analysis of detected genes and peptides. The complementary methods of metagenomics and metaproteomics contribute to a more full characterization of bacterial taxa that are potentially active versus truly metabolically active and thus impact water quality and inter-trophic relationships.

NOAA FISHERIES CONTRIBUTIONS TO IMPROVING THE REGULATORY REALM IN OREGON & WASHINGTON
Dan Tonnes* and Kalloway Page
NOAA Fisheries has contributed to a number of initiatives to improve information available and streamline shellfish permitting. This presentation will describe these initiatives and seek further input on how we can continue to make progress over the next year.

BUILDING AN ESTUARINE ECOSYSTEM MANAGEMENT COLLABORATIVE FOR WILLAPA BAY AND GRAYS HARBOR

Nicole Naar*, Jackson Blalock, Sean McDuff, and Brent Vadopalas

The Washington Coast Shellfish study emerged from a confluence of long-standing but continually evolving issues facing shellfish farmers and resource management agencies in Willapa Bay and Grays Harbor, specifically the challenges posed by (1) interactions between shellfish aquaculture and eelgrass and (2) burrowing shrimp management. The goal of the project is to sustain shellfish aquaculture in the estuaries under changing environmental conditions by establishing a collaborative, ecosystem-based management framework. In this talk, we will present study results to date, share lessons learned from our hybrid working group process, and reflect on our progress toward building an ecosystem-based management collaborative.

EXAMINING THE INTERACTION OF SHELL DEVELOPMENTAL STRATEGY AND OCEAN ACIDIFICATION ON LARVAL PACIFIC RAZOR CLAMS (*SILIQUA PATULA*)

Marina Washburn*, Jeff Hetrick, Jacqueline Ramsay, and Amanda Kelley

Ocean change, facilitated by the increase of anthropogenic carbon dioxide is driving oceanic chemical changes resulting in a long-term global decrease in ocean pH, colloquially termed ocean acidification (OA). Previous studies have shown that OA can have negative physiological consequences for calcifying organisms, particularly bivalves. This study examines the effects of ocean acidification- increased pCO2 and lowered pH on larval *Siliqua patula*, the Pacific razor clam. Experimental work was conducted during the summer of 2018 at the Alutiiq Pride Shellfish Hatchery in Seward, Alaska. Larvae were spawned and cultured over a month until the juvenile phase was reached under three future OA scenarios. The treatments include a static high pCO2 of 867 µatm/7.7 pH units (projected for the year 2100, based on in situ pH measurements with a -0.3 pH offset), variable pCO2 of 357 µatm/8.0 pH units to 867 µatm/7.7 pH units, and current ambient pCO2 of 357 µatm/8.0 pH units. The variable treatment fluctuated between the static high treatment and the static, current ambient treatment on a diurnal cycle. A much-needed developmental time-series was also assembled for S. patula. Response variables include analysis of shell growth rate, shell mineralization, shell composition, and shell dissolution, as well as changes in gene expression- via mRNA expression levels for both HSP-70 and Carbonic Anhydrase, two genes identified as bioindicators of OA stress. During preliminary analyses of experimental samples, it was discovered that *S. patula* utilizes a relatively unique form of shell development, more often found in gastropods. This has led to new investigations regarding shell development during early life stages. The new analyses employed for this study include further compositional examination and mineral structure analysis. Understanding exactly how this unique process of shell development occurs in *S. patula* is critical not only to understanding how *S. patula* may be affected by elevated pCO2, but also to opening new avenues of research into possible "winners and losers" in an acidified ocean.

KELPOST! KELP, CARBON SEQUESTRATION AND PASTURE MANAGEMENT

Eli Wheat*, Nathan Mock, and Meg Chadsey

No abstract submitted.

DEVELOPMENT AND IMPLEMENTATION OF THE ALASKA AQUACULTURE PERMITTING PORTAL

Hannah Wilson*, Alicia Bishop, Michelle Morris, Garold Pryor, Roberta Budnik, Carol Brady, Kimberly Stryker, Andrew Miller, and Brittney Smith

Alaskans' interest in shellfish and seaweed farming is growing. Both the Alaska Mariculture Development Plan in 2018, and the NOAA Fisheries Alaska Mariculture Workshop Summary Report in 2020, identified the need for a central clearing house of aquaculture permitting information and an online permitting portal to aid aquaculture applicants. This nascent industry often found the permitting process confusing and cumbersome. Farmers are required to file multiple permits with four or more state and federal agencies, for a permitting process that can take years. To address this barrier, NOAA Fisheries Alaska Region and Alaska Sea Grant partnered to create user-friendly tools to guide applicants through the permitting process. A working group of state and federal agencies involved in permitting aquatic farms reviewed each permitting step and drafted tools to help navigate the process. Prospective and existing farmers then reviewed the materials for usability. Experienced farmers provided additional feedback and suggestions for applicants to consider before starting the application process and siting a farm. Currently the working group is developing a downloadable PDF permitting guidance document for users, along with creating a web-based permitting portal. Both resources contain: "before you start" guidance; an application process step-by-step guide and accompanying flowchart; siting information; permit amendment, renewal, and transfer information; resources for new growers; and the basics of aquaculture governance in Alaska. The portal is scheduled to go live in time for the 2022 application cycle.

SHELL-BORING POLYCHAETE PESTS OF OYSTERS: PERSPECTIVES FROM THE US PACIFIC NORTHWEST

Chelsea Wood*, Julieta Martinelli, Megan Considine, Steven Rumrill, Jacqueline Padilla-Gamino, Lorenz Hauser, and Teri King

Infestations of mud worms – parasitic polychaetes in the genus Polydora – are responsible for substantial losses to commercial oyster industries worldwide. These polychaetes burrow into the shells of bivalves and cause unsightly blisters that release detritus, mud, and fecal material, fouling oyster meats. Even when blisters remain intact, they compromise the aesthetic presentation of oyster meats on the shell and reduce an oyster's value for canning or smoking. Although these pests are globally distributed, the Pacific Northwest had - until recently - been free of shell-boring polychaetes. In 2020, our group documented *Polydora websteri*, a notorious shell-boring species, in Washington State waters for the first time. Since then, we have detected shell-boring polychaetes at sites throughout the Pacific Northwest. In this workshop, we will present our research to date, including our estimates of the distribution of various shell-boring

polychaete species and results of experiments to test treatments that might help oyster farmers control infestations of these worms.

IS THE EUROPEAN GREEN CRAB IN OREGON NOW ABUNDANT ENOUGH TO BE SELF-RECRUITING?

Sylvia Behrens Yamada*, Jennifer L. Fisher, P. Michael Kosro, and Shon S. Schooler

Annual recruitment of Young-Of-the-Year European green crabs, *Carcinus maenas*, in Oregon estuaries varies greatly with ocean conditions. Numbers were high following the 1997-1998 El Niño, decreased and remained low until they spiked again following the 2015-2016 El Niño. Among the best indicators for green crab year class strength are warm winter water temperatures, and a high abundance of southern copepods. These correlations suggest that green crabs need (1) warm winters (temperature >10°C), which enable larvae to complete their development in the near-shore, (2) strong northward flow of coastal waters during winter, which allows larvae to be transported from established populations in California and (3) coastal circulation patterns that keep larvae close to shore, where they can be carried by wind and tidal currents into estuaries to settle. Ocean indicators prior to 2016 strongly suggest that Oregon green crabs originated from California larval sources. Over the last few years, however, this relationship appears to be breaking down in that more young green crabs were observed than predicted from ocean indicators. We discuss the possible role of additional larval sources from the north and from local reproduction.

RESURGENCE OF THE OYSTER INDUSTRY IN TOHOKU REGION, JAPAN, FOLLOWING THE 2011 TSUNAMI, BY ADOPTING SINGLE SEED CULTURE METHODS

Takehiro Yoshimoto*

Miyagi is home of Pacific Oyster. When the tsunami came, it decimated the oyster industry in Miyagi and surrounding area Tohoku, with many farmers losing their lives, family members, and livelihoods. 98% of the industry’s infrastructure, including oyster rafts, work facilities and oyster culture beds were lost. However, even prior to the tsunami, the industry was in trouble. Japan is a large oyster producer, but most of the farmers use traditional methods that produce low value produce, shelled meat product, and hence annual earnings of a coastal fishery household are low. Because of these ties, and because Australia has now become the world leader, in 2013, I, Snr Business Development Manager at a Japanese office of Australian Trade Commission sought to identify how Australia could contribute to the reconstruction of the oyster industry in Tohoku. We consulted with local farmers and fishery associations and found that the Tohoku industry was seeking to modernise its techniques, increase the quality of its product, and become a viable industry in the future. To help farmers rebuild the aquaculture industry, we, Australian Government, and business collaborated to introduce Australian expertise and technology into Miyagi and the Tohoku region. For example, we hosted an Australian Oyster Culture Technology Seminar in Miyagi, in February 2014 which was attended by around 100 oyster farmers. One Japanese

industry leader described this event as a ‘turning point’ in the region’s reconstruction. The farmers were interested to hear how Australia overcame challenges similar to those that the farmers were facing – an ageing population, unstable income and gruelling work. They heard about single seed farming and Australian technologies which have automated and increased efficiency. Then in June 2014, we took 12 Japanese oyster farmers to Tasmania, including three from Miyagi Prefecture. The four-day program enabled delegates to work on Australian farms to experience for themselves what Australian technologies could do for them in practice. Since I join SEAPA and represent its Japanese entity three years ago, I see continuous development in the industry. Katakura Shoten, for example.