SESSION 7

FUTURE/POC Topic Session
Predictions of extreme events in the North Pacific and their incorporation into management strategies

S7-LiveOral-1 (PaperID=15054)

Recent advances in measuring and predicting the occurrence and impacts of harmful algal biotoxins in British Columbia coastal waters

Andrew R.S. **Ross**[1], Blair Surridge[2], Harry Hartmann[2], Mackenzie Mueller[3], Ovi Haque[4], Tim Hewison[5], Nicole Frederickson[6], Stewart Johnson[7], Ryan Shartau[7], Lenora Turcotte[7], Andrea Locke[1], Melissa Hennekes[1], Nina Nemcek[1], Hayleigh Shannon[1], Akash Sastri[1] and R. Ian Perry[7]

1 Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney BC, Canada
E-mail: Andrew.Ross@dfo-mpo.gc.ca
2 M.B. Laboratories, Sidney BC, Canada
3 Department of Biology, University of Victoria, Victoria BC, Canada
4 Cermaq Canada Ltd., Campbell River BC, Canada
5 Grieg Seafood British Columbia Ltd., Campbell River BC, Canada
6 Citizen Science Program, Pacific Salmon Foundation, Vancouver BC, Canada
7 Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo BC, Canada

The frequency and magnitude of marine harmful algal blooms (HABs) appear to be increasing worldwide, influenced by factors such as eutrophication and climate change. Algal biotoxins and physical damage caused by HABs have a negative impact on marine life including fish, mammals and seabirds and can result in significant losses to the aquaculture industry. Variations in the timing, extent, duration, and impact of toxic HABs have been linked to changing environmental conditions, including extreme events such as the 2014-2016 North Pacific marine heatwave. Scientists at Fisheries and Ocean Canada are partnering with the aquaculture industry and citizen scientists to collect biotoxin samples, taxonomic and environmental data in British Columbia (BC) coastal waters. The goal of this research is to identify the biotoxins responsible for impacting wild and farmed species, and the environmental conditions and mechanisms that give rise to these impacts. To enable this research, new methodology has been developed to quantify multiple biotoxins in seawater and phytoplankton, including toxins associated with amnesic, paralytic and diarrhetic shellfish poisoning in humans. The method is being used to generate spatial and temporal profiles of harmful algal biotoxins in BC coastal waters, including aquaculture facilities and critical habitat for marine mammals and their prey (e.g. salmon). Initial results suggest that biotoxin concentrations may be related to water temperature as well as the presence of associated harmful algae. Such information can be used to help predict and manage the impacts of toxic algal blooms on marine fisheries and ecosystems in the North Pacific.

S7-LiveOral-2 (PaperID=15133)

The next decade of ocean acidification research in the Bering Sea: What we've learned and what's coming next

Jessica N. **Cross**[1], Darren Pilcher[2,1], Hongjie Wang[2,1], Elizabeth Siddon[3], Natalie Monacci[4], W. Christopher Long[5], and Esther Kennedy[6]

1 NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA. Email: jessica.cross@noaa.gov
2 University of Washington Cooperative Institute for Climate, Oceans, and Ecosystem Science, Seattle, WA, USA
3 NOAA Alaska Fisheries Science Center, Juneau, AK, USA
4 University of Alaska Fairbanks Ocean Acidification Research Center
5 NOAA Alaska Fisheries Science Center, Kodiak, AK, USA
6 University of California, Davis, Davis, CA, USA

Over the last decade, ocean acidification (OA) has emerged as one of the most prominent issues in Alaskan marine research, and a possible threat to culturally and commercially important marine resources. Multiple communities around the state are now engaged in their own OA studies and monitoring, and are asking a common question: what risks does my region face? These are especially salient questions for Alaskans, given that the intensity, duration and extent of OA events have been greater than other ocean basins. Given the pace of the observed changes due to OA around Alaska, the area is commonly referred to as a bellwether and the proverbial "canary in the coal mine" for the rest of the global ocean. Here, we will take a look back at the last ten years of OA research in the Bering Sea, and highlight new, cutting-edge synthesis and biogeochemical modeling, forecasting, and projection efforts that have dramatically increased our capacity to understand Alaskan OA from a large-scale perspective just in the past year. For example, we have scaled point observations to the entire Bering Sea shelf to show that corrosive conditions have covered almost 60% of critical habitat areas in the last ten years. Our goal is to continue refining our capacity to identify new risks and emerging resilience of Alaskan ecosystems, and guide sound, evidence-based decisions that support sustainable marine resources in the future, including the evaluation of marine carbon dioxide removal techniques.

S7-LiveOral-3 (PaperID=15134)

Tropical influence on the development of Northeast Pacific marine heatwaves

Antonietta **Capotondi**[1,2], Matthew Newman[1,2], Tongtong Xu[3] and Emanuele Di Lorenzo[3]

1 University of Colorado, CIRES, Boulder, CO, USA. E-mail: antonietta.capotondi@noaa.gov
2 NOAA Physical Sciences Laboratory, Boulder, CO, USA
3 Georgia Institute of Technology, Atlanta, GA, USA

Starting in Winter 2013/14, the Northeast Pacific experienced extremely warm sea surface temperatures (SSTs) that began in the center of the Gulf of Alaska and subsequently extended along the U.S. West Coast, where they persisted into 2016 with evolving intensity and spatial pattern. Building on previous research showing that intense Northeast Pacific warming events undergo similar evolutions, in this study we explore large-scale deterministic influences on Northeast Pacific MHW development, and the degree of predictability of these events. A Linear Inverse Model (LIM), constructed from both SST and sea surface height (SSH) monthly anomalies, is used to determine the optimal precursors of Northeast Pacific MHWs at different lead times. Our analysis identifies initial precursors anomalies characterized by weak SST anomalies in the Northeast Pacific, subtropical anomalies reminiscent of the Pacific Meridional Mode, as well as warm conditions in the central equatorial Pacific, and by SSH anomalies that achieve their largest values in the tropical Pacific and are consistent with off-equatorial Rossby wave dynamics. These optimal initial conditions develop into Northeast Pacific MHWs after two-to-three seasons, in conjunction with the development of Central Pacific (CP) El Niño conditions in the tropical Pacific. Diagnosis of the key ENSO eigenmodes determined from the LIM dynamical operator, which represent different aspects of evolving ENSO diversity, is used to examine their respective roles in the subsequent growth of the MHW. This analysis demonstrates a key role for ocean dynamics and especially for tropical CP El Niño conditions, in sustaining that growth.

S7-RecordedOral-4 (PaperID=15017)

Co-occurrence of California drought and northeast Pacific marine heatwaves under climate change

Hui **Shi**[1*], Marisol García-Reyes[1], Michael G. Jacox[2,5], Ryan R. Rykaczewski[3], Bryan A. Black[4], Steven J. Bograd[2], and William J. Sydeman[1]

1 Farallon Institute, Petaluma, CA 94952, USA. E-mail: daisyhuishi@faralloninstitute.org
2 NOAA Southwest Fisheries Science Center, Environmental Research Division, Monterey, CA 93940, USA
3 NOAA Pacific Islands Fisheries Science Center, Ecosystem Sciences Division, Honolulu, HI 96818, USA
4 University of Arizona, Laboratory of Tree-Ring Research, Tucson, AZ 85721, USA
5 NOAA Physical Sciences Laboratory, Boulder, CO 80305, USA

From 2013–2016, an exceptional California drought co-occurred with extreme northeast Pacific marine heatwaves, leading to significant social-economical-ecological impacts. The evolution of this event led us to examine California drought co-occurring with marine heatwaves in the California Current and in the Gulf of Alaska, as well as other relevant sequential events. To separate effects of long-term trends from year-to-year changes, we examine the changes with and without trends respectively. Here, we show that under global warming, the co-occurrences of extreme warm northeast Pacific ocean and dry California conditions will become dramatically more frequent by the end of the 21st century. This increasing frequency of co-occurrence is strongly driven by anthropogenic warming and drying trends. If these trends are removed, the co-occurrence between Gulf of Alaska marine heatwaves and California drought will increase relative to cases with no warming, but the co-occurrence of California Current marine heatwaves and California drought remains unchanged. We also found stronger links between the marine heatwaves in the Gulf of Alaska and subsequent marine heatwaves in the California Current, and reduced frequency of persistent California droughts. Understanding changes not just in extremes but in their co-occurrence is critical to projecting the future impacts of multiple ecosystem stressors.

S7-RecordedOral-5 (PaperID=15139)

Detecting and identifying saxitoxin-producing algae in the Salish Sea

Brandi Cron Kamermans and Melissa Peacock

Salish Sea Research Center, Northwest Indian College, 2522 Kwina Road, WA, 98226, U.S.A.
E-mail: bkamermans@nwic.edu

The Salish Sea, a network of waterways along the coast of British Columbia, Canada and the state of Washington, United States is home to the Coast Salish People. Residents, including the Lummi People, rely on shellfish for subsistence harvesting. The goal of our project is to detect harmful algae blooms in the ecosystems along the coast of the Lummi Nation. The Salish Sea Research Center currently monitors harmful algae with microscopy, but we are exploring the feasibility of incorporating a commercially produced quantitative polymerase chain reaction (qPCR) assay. Preliminary results have enabled us to detect the gene responsible for producing saxitoxin (*SxtA4*), one of the Paralytic Shellfish Toxins that can cause harm to humans if ingested. Plans to develop a new qPCR assay to identify *SxtA4* produced by *Alexandrium catenalla,* a species of concern in our study area, will be presented. The inclusion of qPCR methods will rapidly and accurately detect genes known to threaten food sovereignty and human safety in the Salish Sea.

S7-RecordedOral-6 (PaperID=15160)

Extreme events in the thermal state of the Far-Eastern Seas and adjacent waters of the Northwestern Pacific

Elena **Ustinova**

Pacific branch of Russian Federal Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, Russia
E-mail: elena.ustinova@tinro-center.ru

In this study extreme events in the thermal state of the Far-Eastern Seas and adjacent waters of the Northwestern Pacific were analyzed using regional datasets based on historical observations. In the Far-Eastern Seas, the frequency of extreme situations has increased in the last 20 years. Extremely warm and cold winters were characterized by strong atmospheric anomalies with the change in the trajectory of cyclones. Since the middle of 1980s the well-known contrast in the oscillation phases of ice coverage in the Okhotsk and Bering Seas have been disrupted. However, in some "extreme" years the ice cover anomalies of the Okhotsk Sea were in opposite phase with the Bering Sea. The formation of strong winter atmospheric anomalies over the Far-Eastern region causes the fast response in large ice cover anomalies. During the warm period, the position and intensity of the summer centers of atmospheric action, especially the ridge of the Pacific anticyclone (for example, its impact on the Japan Sea in the summer of 2021), affect the formation of extreme SST anomalies in the region. Local events can also generate extreme anomalies affecting the spatial distribution, migration routes, and possibly changes in the abundance of short-cycle fish species such as Pacific saury. For example, large anticyclonic eddy with extreme temperature anomalies located east off Hokkaido Island in 2015-2016 caused a shift in the autumn southern migrations of saury from coastal areas to the open waters. Subsequently, the abundance of saury decreased significantly in the areas of traditional fishing.

SESSION 7

FUTURE/POC Topic Session
Predictions of extreme events in the North Pacific and their incorporation into management strategies

S7-E-poster-1 (PaperID=15088)

The effects of ocean data assimilation on North Pacific marine heatwave prediction

Huihang **Sun**[1], Yiguo Wang[2] and Jingjia Luo[1*]

[1] Institute for Climate and Application Research (ICAR), Nanjing University of Information Science and Technology, Nanjing 210044, China. E-mail: jjluo@nuist.edu.cn; jingjia_luo@hotmail.com

[2] Nansen Environmental and Remote Sensing Center, Bjerknes Centre for Climate Research, Bergen, Norway

Marine heatwave (MHW) is prolonged, extremely warm water events over the upper ocean. It can substantially lead to ecological and socioeconomic impacts, and therefore have significantly scientific interests. The 2013-2015 North Pacific MHW was the most famous MHW with a long duration, remarkable intensity, and huge impacts, called The Blob in the scientific literature and media.So far, many studies focued on the physical drivers of the MHW, but there are few studies on improving the prediction skill of the MHW. Based on NUIST-CFS1.0 (i.e., previously SINTEX-F) that had used coupled Sea Surface Temperature (SST)-nudging initialization method, we employ the ensemble Kalman filter (EnKF) to assimilate SST, altimeter satellite gridded sea level anomalies, in situ temperature and salinity profiles to improve the MHW prediction skill. We assess the differences in the North Pacific initial fields and prediction skills at lead times of up to 24 months with and without the ocean data assimilation. The results show that the North Pacific initial conditions are improved largely with the ocean data assimilation, and the North Pacific mean prediction skills of SST and subsurface temperature with EnKF are improved at 1-24 months lead. The ocean data assimilation also improves the prediction skill of the Blob event, especially the prediction skill of regional subsurface temperature. The prediction skill of strong subsurface temperature anomalies in the North Pacific is largely improved with ocean data assimilation, which can also help predict the origin and development processes of the MHW.