Observing the presence of harmful algae on Heceta Bank, Oregon and its relation with domoic acid

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Purpose: The harmful algae *Pseudo-nitzschia* is historically present on the west coast of the United States, and is known to produce a biotoxin domoic acid that can lead to closures of commercial and recreational shellfish and Dungeness crab fisheries. The availability of toxic *Pseudo-nitzschia* cells in the nearby environment where crabs live likely induces prolonged impacts on the safe harvest of crabs. This project aims to collect *Pseudo-nitzschia* data from near-bottom waters in the Heceta Bank area – a harmful algal bloom hotspot in Oregon. Work is being carried out through collaborations with the Oregon Department of Fish and Wildlife and local crab fishermen. This project will provide information about *Pseudo-nitzschia* in near-bottom waters and how its annual blooms affect the valuable Dungeness crab fishery in Oregon.

Summary (activities and accomplishments): The main objective is to characterize potentially toxic Pseudo-nitzschia (PN) species abundance and distribution in the near bottom environment offshore of central Oregon in order to understand PN bloom impacts on domoic acid (DA) concentrations accumulated in Dungeness crabs. Totally 98 samples for quantification of PN abundance in both the surface and near bottom water were collected spanning the coast (**Figure 1**). The specific sampling events were listed in Table 1. The Rocky reef rockfish program (L. Rasmuson) collected PN samples from the near shelf bottom in the Heceta Bank area (central OR coast) during Sept-Nov 2018; Oregon Dungeness Crab management program (K. Corbett) collected PN samples from the near shelf bottom coastwide (12 sub-areas, A to L, Figure 1) in early Nov 2019 while conducting the annual crab pre-season survey; Monthly/biweekly cruises along the Newport Hydrographic line (NHL), occasionally along the central-southern OR coast via ship opportunity by NOAA-NWFSC collected surface and/or bottom water samples throughout the project period. By the end of June 2019, all collected water samples had been processed and analyzed in the laboratory for the abundance of the large cell type of PN (Pnl) and the small cell type of PN (Pns), followed by data input and quality control. The Pnl was further divided into Pn wide cell type and Pn medium cell types whenever possible under the light microscope identification based on the dimension measurement of an individual cell width. Data analysis and synthesis were conducted to overview the temporal patterns of PN cell presence and abundance changes during/post-fall transition time in 2018, pre- and during spring transition in 2019 and the coastwide responding differences in PN presence and abundance to physical conditions particularly during the post-fall transition in 2018. Lastly implications derived from the observed PN patterns were summarized to hopefully inspire more process studies of DA toxicity transfer to Dungeness crabs (and other organisms in the food webs) along the Oregon coast.

Table 1 Field sampling summary during Sept 2018 – May 2019

Sources	Samples Total	Scale
Rockfish (Sep-Nov, 2018)	6	temporal
Crab preseason (Nov, 2018)	34	coastwide
NHL (Sep-Dec, 2018)	27	temporal&cross-shelf
NHL (Feb-May, 2019)	17	temporal&cross-shelf
Ship opportunity (Apr-May, 2019)	14	central/southern Coast
Total	98	

Results: Combining currently available PN abundance data from September 2018 to May 2019 along with DA test results by the Oregon Dept. of Agriculture via the regulations of ODFW during the 2018 project period, some main conclusions are: The usual formation of the diatom *Pseudo-nitzschia* (PN) bloom along the Oregon coast, including the more toxic species type like *P. australis* and the less toxic ones, are subject to a set of regional meteorological and physical ocean conditions, for example, sun radiation, coastal wind and upwelling patterns, nutrient concentrations, *et al*. In Sept-Oct 2018, a toxic PN bloom was first initiated off the southern OR coast following an upwelling favorable north wind and causing the first above Dungeness crab safe harvest level for DA. The following winter storms pushed the toxic PN cells (*P. australis*) northward and shoreward. By early November, the Dungeness crab preseason coastwide survey caught an ongoing PN bloom offshore of the northern and central coast, and the decline of PN bloom in the surface of southern coastal water. However, abundant toxic cell frustules sourced from the Sept-Oct blooms were observed at the near-bottom water off the southern coast, which explained the prolonged domoic acid (DA) contamination to crabs (and the largely benthic environment) through at least December. The strongest winter storm and the northward Davidson Current in late November brought the toxic *P.australis* cells further up to the northern coast leading to a rare DA elevation in December 2018. In Feb-Mar 2019, some weakly north winds induced a winter diatom bloom with some early growth of PN cells, and the dominance of northward wind and current for the time led to a coast-wide spreading of PN. DA increased again in Dungeness crabs in Feb-Mar was associated with the corresponding presence of the toxic *P. australis* in the southern OR coast. Although the number of PN cells was low in late winter, the few cells functioned as the seeds of a larger spring bloom that was observed following the spring transition in mid-April. The survey from late April to early May observed coherent PN blooms along the central and southern coast. Higher surface cell abundance extended offshore of Newport and Heceta Head. The corresponding near bottom PN abundance, however, were low, indicating that the strong spring upwelling and offshore surface Ekman transport kept the PN bloom in the upper water column and away from nearshore (lessen the toxicity to shellfish and crabs if any then). An exception is the increase of DA in crabs in May was matched in time with the toxic PN bloom observed both in the surface and also near bottom offshore of southern OR. Both our fall 2018 and winter-spring 2019 results confirmed that the presence and persistence of toxic PN cells caused DA contamination to Dungeness Crabs and the fall-winter season provides a higher chance of such toxicity threat.

Lessons learned that might help others doing similar work.

- Toxic PN bloom monitoring should be enhanced in the fall-winter time period especially in years when upwelling and downwelling show abnormal seasonal alternations. When evaluating risks of PN toxicity effects to the nearshore ecosystem, physical factors, such as the typical summer upwelling events and Ekman offshore transport are important components in terms of both positively sustaining high species diversity diatom blooms, but also in regulating the distribution of bloom species including those that are toxic. Finer temporal and spatial scale synthesis of physical context and biological status will help to inform reasonable decisions for shellfish and crab harvesting management.

- Fall toxic PN blooms seem to bring in higher risks of toxicity impacts on crabs coastwide: toxic cells sink more efficiently to the near-bottom water under an increasing dominance of downwelling favorable winds, downward advection and mixing, and persistent northward and shoreward transport. Toxic PN bloom impacts to the nearshore and benthic environment around spring transition time could be lessened by increasing predominance of upwelling favorite winds, offshore Ekman transport and stratified water column with cells being suspended more likely in the surface layer.
- From this one-year time scale study, we found that medium and thin size classes of PN were more available in the north while the wide size PN, including the toxic *P. australis* were more readily found in the south. The southern OR coast is therefore more likely to suffer from toxic PN blooms than the central and northern coast, hence the need for consistent southern offshore data collection to study bloom initiation mechanisms and DA production. PN cell growth in late winter is under several commonly known limitations such as low solar radiation, shorter photoperiods and, therefore, with the multiple stressors, PN cells physiologically might turn to be more toxic mode. Once stressors are eliminated, high DA could be synthesized. It is a set of external factors combined to determine chances of toxic PN bloom occurrence, timing and magnitude and spatial patterns.
- As the direct testing results showing that Dungeness crabs in the southern OR coast (south of Cape Blanco) got contaminated by DA more likely than the north during a coastwide toxic bloom, we speculate that crabs natural spatial distribution, behavioral response to external physical disturbances along with local geographic features also account for the differential toxicity effects coastwide.
- PN data and key environmental factor data are still needed to understand multiple paths of the initiation of PN bloom during spring and fall transition time for each specific species at finer time and spatial scales from nearshore to offshore.
- Quantify vertical fluxes of PN cells and DA concentration along the Oregon coast. How weather, physical and chemical factors together make seasonal differences in downward transport efficiency, consequently differences in toxicity potential to both pelagic and benthic food chains.
- More crab food ecology studies (to infer DA transfer pathway) and physiological effects on crabs due to DA long time lingering in their prey and habitats.

Outcomes: Project information was shared promptly with project collaborators: the Dungeness crab fishery team (Kelly Corbett and Daniel Sund) and Marine Fishery Programs (Leif Rasmuson's marine fishery program team). The sampling during the Dungeness crab preseason survey involved local fishermen along the entire OR coast. K. Corbett and D. Sund provided professional training of taking HAB samples and educated HAB effects on Crab fishery and the scientific benefits of this project. The annual Dungeness Crab newsletter assembled by ODFW marine resource program was released in Nov 2018 which broadly introduced this project to a variety of audiences. Research findings are communicated with other HAB programs (e.g. NOAA-PNWHAB), OSU/HMSC scientists and the public from formal/informal meetings, presentations at HMSC seminar series, HMSC Marine Science Day. Research findings are expected to bring in new thinking and methodologies for HAB research in the Heceta Bank area, and for more process studies on HAB and interconnections with the broader pelagic and benthic biological communities and physical environments. Data and findings from this

project will contribute to drafting a manuscript about a long term observation of PN inter-annual and seasonal patterns in the Oregon coastal water.

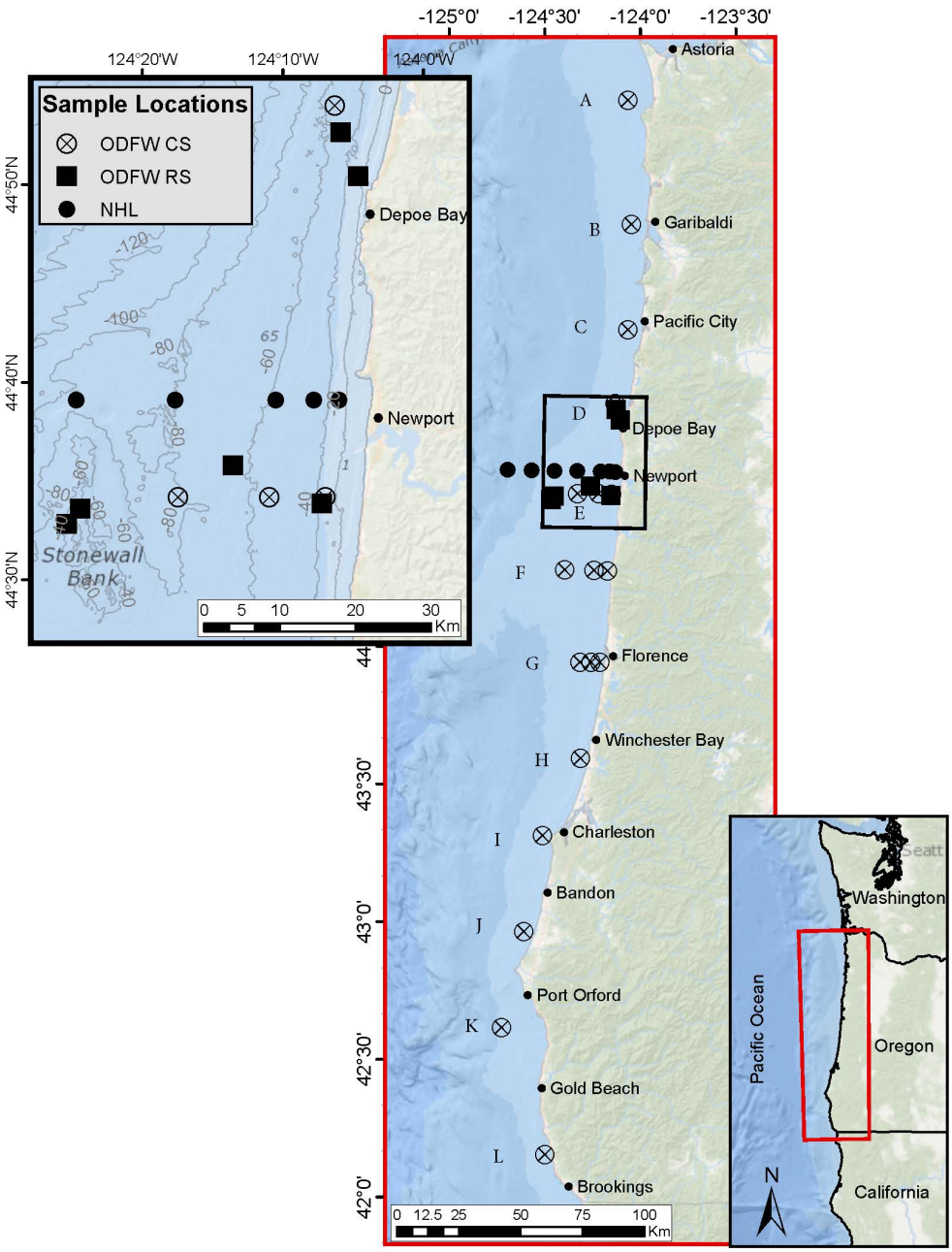

Figure 1. Sampling sites by ODFW Rocky reef rockfish survey (RS, squares) at Seal Rock, Stonewall Banks and Government Camp, Newport Hydrographic Line cruises (filled circle), and ODFW Dungeness Crab preseason survey (CS, open circle) including subarea from the north area A to the most southern area L. The zoomed in map in the upper left gives clearer site locations in the Heceta Bank area.