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Economic and sociocultural impacts of fisheries closures in two fishing-dependent communities following the massive 2015 U.S. West Coast harmful algal bloom

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ABSTRACT

In the spring of 2015, a massive harmful algal bloom (HAB) of the toxin-producing diatom *Pseudo-nitzschia* occurred on the U.S. West Coast, resulting in the largest recorded outbreak of the toxin domoic acid and causing fisheries closures. Closures extended into 2016 and generated an economic shock for coastal fishing communities. This study examines the economic and sociocultural impacts of the Dungeness crab and razor clam fisheries closures on two fishing-dependent communities. Semi-structured interviews were conducted with 36 community members from two communities impacted by the event – Crescent City, California and Long Beach, Washington. Interviewees included those involved in the fishing, hospitality, and retail industries, local government officials, recreational harvesters, and others. Interviews probed aspects of resilience in economic, social, institutional, and physical domains, based on the contention that community resilience will influence the communities' ability to withstand HAB events. Dimensions of vulnerability were also explored, encompassing sensitivity of the communities to HAB events and their adaptive capacity. Common themes that emerged from the interview responses indicate that economic hardships extended beyond fishing-related operations and permeated through other sectors, particularly the hospitality industry. Significant barriers to accessing financial and employment assistance during extended fisheries closures were identified, particularly for fishers. Long-held traditions surrounding crab and shellfish harvest and consumption were disrupted, threatening the cultural identities of the affected communities. Community members expressed a desire for clearer, more thorough, and more rapid dissemination of information regarding the management of fisheries closures and the health risks associated with HAB toxins. The likelihood of intensifying HABs under climate change heightens the need for actions to increase the resilience of fishing communities to the economic and sociocultural impacts caused by HAB-related fisheries closures.

1. Introduction

Many coastal communities on the west coast of the U.S. remain tightly tied to fisheries resources. At least 123 communities in Washington, Oregon and California can reasonably be described as fishing communities (Norman et al., 2007). Such communities are identified in the Magnuson-Stevens Fisheries Conservation and Management Act as being "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs" (U.S. Department of Commerce, 1996). Perturbations to the fisheries that these communities rely on can reduce fishing opportunities and decrease landings, causing economic impacts, erode cultural identity, and negatively affect the physical and mental health of individuals (Hanna and Hall-Arber, 2000; Anderson et al., 2003; Clay and Olson, 2008; Martin, 2008; Olson, 2011; Colburn and Jepson, 2012; Himes-Cornell and Kasperski, 2016). These sociocultural consequences can propagate through fishing communities to impact individuals who are not directly involved in fisheries. Poor mental health, decreased life expectancy, increased poverty, alcoholism, drug use, and an overall loss of cultural identity have been documented in

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communities that suffer long-term declines in fisheries (Hanna and Hall-Arber, 2000; Martin, 2008; Olson, 2011).

Recognition of these impacts has primarily emerged from examining disruptions to fishing resulting from the collapse of fisheries, introduction of policies and management strategies to reduce fishing effort and allow stocks to recover, and social pressures to fishing communities such as gentrification. Despite evidence of harmful algal blooms (HABs) significantly disrupting important fisheries, few economic and social impact assessments of HABs have been performed and formal documentation of the sociocultural consequences is minimal (Jewett et al., 2008). Commercial fishery impacts from HABs result from harvest losses of fish and shellfish resources due to contamination with HAB toxins and farmed fish kills (Conte, 1984; Evans and Jones, 2001; Hoagland et al., 2002; Jin et al., 2008). Losses can also occur to the seafood industry due to sales volume loss from diminished consumer confidence in seafood safety (Lipton, 1998). Other societal costs of HABs include public health (human sickness and death) (Hoagland et al., 2009), recreation and tourism (Evans and Jones, 2001; Oh and Ditton, 2005; Larkin and Adams, 2007; Morgan et al., 2009; Dyson and Huppert, 2010), beach cleanup (Evans and Jones, 2001), and monitoring and management costs (Hoagland et al., 2002). At a national level, the annual economic impact of HABs in the U.S. is estimated at up to $83 million, but this is a highly conservative estimate and the authors acknowledge that single events can occur that equal or exceed the annual average of HAB impacts for the entire nation (2000 dollars; Hoagland et al., 2002). Studies of the sociocultural impacts of HABs in coastal communities are even more limited. A snapshot of the lived realities of six local residents in Cornwall, U.K., identified a loss of sense of place and reduced opportunities for recreational and therapeutic experiences at the coast due to HABs (Willis et al., 2018). Willis et al. (2018) argue that cultural insights are needed to contextualize the ecological and economic impacts of HABs in order to arrive at locally appropriate solutions to increase the resilience of individuals and communities to future HAB events.

Without a more complete understanding of the economic and sociocultural impacts of HABs and the ability of communities to respond to them, regulating and governing agencies are challenged to focus their emergency response strategies to provide the most effective assistance. Bauer (2006) outlined a human dimensions strategy for harmful algal research and response, calling for research to (1) develop baseline and event-specific information on communities that may be directly or indirectly affected by HABs, (2) develop rapid assessment techniques for immediate deployment during HAB events, and (3) collect baseline information on institutional arrangements and regulating communities within which governmental decisions are made. Little progress on these research priorities has been made in the past decade and no standardized tools are readily available to describe the social, cultural, and economic impacts of severe HAB events.

Beginning in May 2015, a massive HAB of marine diatoms in the genus *Pseudo-nitzschia* occurred on the U.S. West Coast from California to Alaska (McCabe et al., 2016). Some species of *Pseudo-nitzschia* can produce the toxin domoic acid that can accumulate in filter feeding fish such as anchovies and sardines, and in shellfish such as crabs and bivalves. Human consumption of seafood contaminated with domoic acid can cause amnesic shellfish poisoning, a life-threatening illness characterized by gastrointestinal and neurological disorders (Perl et al., 1990; Teitelbaum, 1990). To prevent acute poisoning by domoic acid, regulatory agencies impose commercial and recreational fisheries closures when toxin levels in seafood exceed regulatory limits for human consumption. While these closures are effective at preventing illnesses, they can generate economic shocks for coastal communities that are dependent on fisheries resources (Bauer, 2006).

The 2015 HAB event resulted in numerous fisheries closures in Washington, Oregon and California that were imposed in May 2015 and continued through the winter and spring of 2016 in some regions. The commercial Dungeness crab and recreational razor clam fisheries were particularly impacted. The commercial Dungeness crab fishery is one of the most important fisheries on the U.S. West Coast, generating high revenues and serving as a dominant node in regional fisheries connectivity networks (Fuller et al., 2017). The 2015 HAB event caused the Dungeness crab fishery opening to be postponed by one month in Washington and Oregon and almost six months in parts of California. Compared with the previous season, the U.S. West Coast commercial Dungeness crab fishery experienced a decrease in revenue of $97.5 million in 2015 (National Marine Fisheries Service, 2016), due in part to the fisheries closures stemming from the HAB event.

The recreational razor clam fishery is highly popular in Washington State. The razor clam season typically occurs in the winter from October through April when many other outdoor recreation activities are not in season. As many as 30,000 razor clam diggers will visit the small coastal communities on the Washington coast in a single day, and many coastal businesses depend on commerce associated with clamming activities for a significant portion of their annual income (D. Ayres, personal comm.). A season-long closure of the recreational razor clam fishery in Washington State, such as occurred in 1998–1999 and 2002–2003, is estimated to result in $24.4 million in annual lost expenditures (2008 dollars; Dyson and Huppert, 2010). In Long Beach, Washington, 54 days of razor clam harvest, or about 40% of the 2015–2016 razor clam season, were lost due to the 2015 HAB event.

The 2015 HAB event was associated with anomalously warm waters in the northeast Pacific Ocean, informally termed the “Blob” (Bond et al., 2015; McCabe et al., 2016). Notably, all of the major *Pseudo-nitzschia* HAB events on the U.S. West Coast have occurred after periods of warming (McCabe et al., 2016; McKibben et al., 2017). Projected warming over the coming decades raises questions about the frequency and severity of future HAB events in this region, and whether or how communities will cope with potentially longer and more frequent fisheries closures. The research reported here sought to (1) identify some of the economic and sociocultural impacts experienced by two U.S. West Coast fishing communities, Crescent City, California and Long Beach, Washington, following the 2015 HAB event and (2) determine how those impacts shape community members’ perceptions of the future.

1.1. Selection of communities

The two focal communities, Crescent City, California and Long Beach, Washington, were selected for this study because (1) they are strongly dependent on fisheries resources and they exhibit social vulnerabilities that could influence their ability to cope with the fisheries closures (NOAA, 2016b), (2) they both have Dungeness crab and razor clam fisheries, with Dungeness crab typically the largest volume and highest value landing in their ports (Pacific Fisheries Information Network (PacFIN), 2017), and (3) they experienced closures to both the commercial Dungeness crab and recreational razor clam fisheries during the 2015 HAB event (Dan Ayers, pers. comm., 2016; McCabe et al., 2016; California Ocean Science Trust, 2016). The first criteria were assessed using the National Oceanic and Atmospheric Administration’s (NOAA’s) economic and social vulnerability index at http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/map (NOAA, 2016b). A cross-section of NOAA representatives and others expanded upon a framework initially developed by Jepson and Colburn (2013) for the U.S. Southeast and Northeast regions to calculate these indices for coastal communities around the U.S. (NOAA, 2016a). Crescent City and Long Beach score medium to high on indicators for fishing engagement and reliance, which represent the importance of commercial fishing to the communities, and score medium to high on most indicators for community social vulnerability (i.e., labor force, housing characteristics, poverty, population composition, and personal disruption). Community social vulnerability indices represent factors that can shape the ability to adapt to change, such as fisheries harvest closures due to HABs (Jepson and Colburn, 2013). These indicators