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Rapid recovery of Dungeness crab within spatial fishery closures declared under indigenous law in British Columbia

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ABSTRACT

Canada's constitution grants indigenous people priority access to marine resources, yet indigenous, commercial and recreational fishers target the same species. Avoiding conflict between different users, therefore, requires evidence-based policies that manage fisheries for conservation while respecting indigenous rights. From 2006 to 2015, Canada's Conservative government demoted the role of science in resource management, stifling research by federal agencies like Fisheries and Oceans Canada. To address ensuing data gaps, during 2014–2015 the Heiltsuk, Kitasoo/Xai'Xais, Nuxalk, and Wuikinuxv First Nations conducted coordinated research on Dungeness crab (*Cancer magister*), a culturally-significant resource. These indigenous groups are experiencing declining catch rates of Dungeness crab and postulate that commercial and recreational fisheries are primary causes of local declines. Accordingly, they applied indigenous laws and declared spatial fishery closures for commercial and recreational fishers at 10 sites (closed) while allowing exploitation by all users to continue at 10 other sites (open). Sampling occurred repeatedly over time and analyses compared temporal trends in population characteristics between closed and open sites. Results were consistent with the hypothesis that fisheries decrease the abundance and size of exploited species, but spatial protection can reverse these effects. The body size and catch-per-unit effort of legal-sized males increased over time at closed sites but declined at open sites. Importantly, fishery status did not affect temporal changes in the relative abundance of unfished classes of crab – sublegal males and females – which is logically consistent with the hypothesis. Our study demonstrates that indigenous governance can create spatial closures for conservation and research when Canada's government fails to do so. Long-term solutions, however, require collaboration in research and management between federal and indigenous governments. Towards that end, Canada's newly elected Liberal government has begun to restore federal science and to address indigenous rights, thereby enhancing the possibility of such collaboration.

1. Introduction

Canada's constitution grants indigenous people priority access to marine resources, yet indigenous, commercial and recreational fishers target the same species. Avoiding conflict between different users, therefore, requires evidence-based policies that manage fisheries for conservation while respecting indigenous rights to fish for food, social and ceremonial

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purposes (DFO, 2007). Between 2006 and 2015, however, Canada's Conservative Government demoted the role of science in resource management, stifling research by federal agencies like Fisheries and Oceans Canada (DFO), hampering evidence-based policies for fishery management (Hutchings and Post, 2013; Turner, 2013), and effectively leaving indigenous people to collect their own data on conservation issues that affect them.

Dungeness crab (*Cancer magister*), an important traditional food for indigenous people of coastal British Columbia, are a case in point. The species lives from southern California to Alaska, yet is well-studied only in northern and southern parts of its distribution. Oceanographic conditions that affect life-history and ecology vary strongly along this 3900-km-long latitudinal range. Therefore, lessons learned from well-studied populations do not necessarily apply to data poor regions (Rasmuson, 2013), such as British Columbia's Central Coast. In that region, indigenous people are experiencing declining catch rates of Dungeness crab and postulate that commercial and recreational fisheries are causing local declines. Federal research programs have yet to address this issue.

Accordingly, during 2014 and 2015 the four Central Coast First Nations – Heiltsuk, Kitasoo/Xai'Xais, Nuxalk, and Wuikinuxv – conducted coordinated research on Dungeness crab. They applied indigenous laws and declared spatial fishery closures for commercial and recreational fishers at 10 sites (closed) while allowing exploitation by all users to continue at 10 other sites (open). DFO chose to not recognize and legislate these closures. Given that indigenous laws arise from collective, long-term observational knowledge and focus on the principles and stewardship practices that have allowed sustainable use of natural resources over many centuries (Trosper, 2003; Housty et al., 2014), Central Coast First Nations considered DFO's decision a lost opportunity for collaboration between different levels of government. Accordingly, each First Nation engaged in public communications asking for compliance from commercial and recreational fishers, and conducted patrols in which they requested non-compliant fishers to remove their traps from closed sites. Sites were sampled repeatedly over time, and the closures were designed to compare temporal trends in population characteristics between closed and exploited sites (Taggart et al., 2004; Wahle et al., 2008). Indigenous fisheries for food, social and ceremonial purposes (FSC) continued at some closed sites, and therefore results provide insight into the effects of non-indigenous fisheries rather than the effects of complete harvest refugia.

By federal law, fishers can retain only male Dungeness crab with notch-to-notch carapace widths of 154 mm or greater. Accordingly, we tested the predictions that declines over time in the relative abundance and size structure of legal-size males would occur at closed but not at open sites, and that closures would have no effect on the abundance of classes not targeted by fishers: smaller males (width < 154 mm) and females. These predictions derive from the well-supported hypothesis that fisheries decrease the abundance and size of exploited species, but spatial protection can reverse these effects (Pauly et al., 2002; Edgar et al., 2014). Although responses to exploitation and protection are best known in fishes (e.g. Claudet et al., 2010 and Shackell et al., 2010), crab appear to respond similarly (Taggart et al., 2004; Wahle et al., 2008).

Our results provided evidence that fishery closures declared under indigenous law – effectively social agreements between First Nations and the public without the benefit of federal legislation – could solve a marine conservation problem, albeit temporarily. More importantly, our study is an example of how First Nations can contribute to applied science, thereby setting the stage for long-term conservation via future collaborations between indigenous and federal governments.

2. Methods

Starting in the spring of 2014, Dungeness crabs were studied at 20 sites distributed throughout the Central Coast (Fig. 1). Sites were sampled approximately every two months over periods ranging from four to 10 months (Table 1). The exceptions were two sites where sampling occurred daily for three weeks in May 2014 and semi-daily for one week in November of 2014 to accommodate a mark-recapture study reported elsewhere (Frid and Boulanger, 2014).

Three types of fisheries – indigenous FSC, commercial and recreational – occurred at all sites prior to the study. At the onset of research, however, indigenous governments declared fishery closures for commercial and recreational fishers at 10 sites (closed sites) while allowing exploitation by all users to continue at remaining sites (open sites) (Fig. 1; Table 1). Traditional knowledge from each indigenous community was used to select closed and open sites across a similar number of inlet, bay and channel locations, and to ensure that all sites contained good habitat for Dungeness crab. The location of closed sites was determined from community input into marine spatial planning processes (MaPP, 2015), which identified these locations as particularly important to indigenous FSC fisheries.

Sampling methods were based on protocols developed by DFO (Dunham et al., 2011). Traps were stainless steel, inlet-type, circular with 91.4-cm diameter and closed escape ports. Bait was Pacific herring (*Clupea pallasi*) placed inside 500-ml vented jars made of plastic and suspended from the centre of the trap's lid. Bait amount was two large or three smaller herring. For each sampling session, 9–10 traps were deployed per site and stratified along three depth contours: <20 m, 25–50 m, and 51–75 m (i.e., 3–4 traps per contour). Exceptions occurred when sites lacked deep habitats (i.e. all 9–10 traps were set shallow: Table 1) and, occasionally, when fewer than 9 traps were available. Depth and location were recorded for each trap. Minimum trap spacing was 100 m, except in small bays where it was reduced to 50–75 m to fit multiple traps. Soak times averaged approximately 24 h (range 16–26 h), except twice during November 2014 at Johnson Bay in which soak times were 2–3 days. For each individual crab, we recorded sex class, notch-to-notch carapace width and shell hardness and other variables not reported here (Dunham et al., 2011).