Snow crab simulations: effects of bycatch in the groundfish fisheries

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Introduction

Sarah Marrinan and Sara Cleaver (North Pacific Fishery Management Council staff) presented information to the Crab Plan Team at its May 2020 meeting on a proposed Council action to change crab PSC (Prohibited Species Catch) limits in the groundfish fisheries to the lowest possible level when the directed crab fishery is closed. There are currently area PSC limits in place for Bristol Bay red king crab, Tanner crab, and snow crab for groundfish vessels using trawl gear. The current limits are rarely exceeded, and even if they were set at the lowest level would rarely be constraining. Council staff asked the CPT about the importance of bycatch in crab population dynamics. Currently there is very little crab bycatch in groundfish fisheries compared to the directed fisheries. However, it was noted that there is very little information on the unobserved mortality of crab species. Thus, Council staff asked if assessment authors could examine the effects of increased bycatch on model results. Consequently, the Crab Plan Team (CPT) requested at its May 2020 meeting that:

"Assessment authors should rerun the assessments for BBRKC, Tanner crab, and snow crab with higher assumed levels of bycatch abundance (increases of 50% and 100%) as a sensitivity analysis. These should be provided to Council staff within the next two months for inclusion in the October Council document."

This report addresses this request for snow crab.

Methods

The methodology implemented here departs slightly from what the CPT requestions. Following, Buck Stockhausen's example, the model was rerun with three bycatch scenarios in which historical bycatch was 50%, 100%, and 1000% larger. In these simulations, all parameters governing biological processes (e.g. recruitment, natural mortality, growth, maturity) were specified to the values estimated in the 2019 assessment. Most parameters governing fisheries processes (directed and discard fishing mortality and directed, discard, and bycatch selectivity) were also fixed. Only fishing mortality associated with bycatch in other fisheries (which is primarily trawl fisheries for snow crab) was estimated to accommodate the newly input bycatch numbers.

Results

Increases in bycatch resulted in a general scaling down of mature male biomass (MMB) at the time of the survey (Figure 1). Females were not affected because the selectivity of the bycatch 'fleet' in the model generally excludes them from mortality (Figure 2). The associated estimated fishing mortality increased predictably with increases in the input bycatch (Figure 2).

The translation of these changes to most management quantities was also predictable (Table 1). Terminal year MMB did not appreciably because the magnitude of bycatch relative to MMB is very small. B35 did not change because the biological processes determining it were fixed. F35 decreased as bycatch levels increased becaues F35 is only related to the directed fishery. As the 'expected' by catch increases (which is determined by input levels), the fishing mortality allowed in the directed fishery has to decrease to compensate.

The changes in the overfishing level (OFL) were less intuitive. As bycatch increased, the OFL also increased. The OFL is calculated as the sum of the retained catch and mortality associated with discards in the directed fishery and bycatch elsewhere. So, the decreases in the retained portion of the OFL resulting from decreases in the FOFL (which themselves are the result of increases in bycatch) are outpaced by the increases in the portion of the OFL allocated to bycatch.

The reason this occurs is related to the selectivity of the bycatch–a fraction of the bycatch is not mature (Figure 2). The harvest control rule only considers mature male biomass when calculating the FOFL (and OFL), but the F allocated for bycatch is fixed and does not consider the amount of MMB (or immature biomass) available. So, as the F allocated to bycatch increases, increases in the contribution of bycatch to

the OFL that is immature are possible. Increases in the amount of immature crab caught do not impact the MMB, so the OFL can increase as bycatch increases without impacting the 'status' of the fishery. This issue could be exacerbated by the large recruitment class coming through the population.

Discussion

Based on these analyses, changes in the amount of bycatch observed would have had the largest impact during the period when bycatches were largest (e.g. the mid 1990s through the mid 2010s). In the most recent years, bycatch has been so small that inputting even 10 times the amount of bycatch reported resulted in very small changes to the terminal year of MMB.

Increases in the OFL

Maybe need to reconsider the way immature bycatch is treated in the harvest control rule.

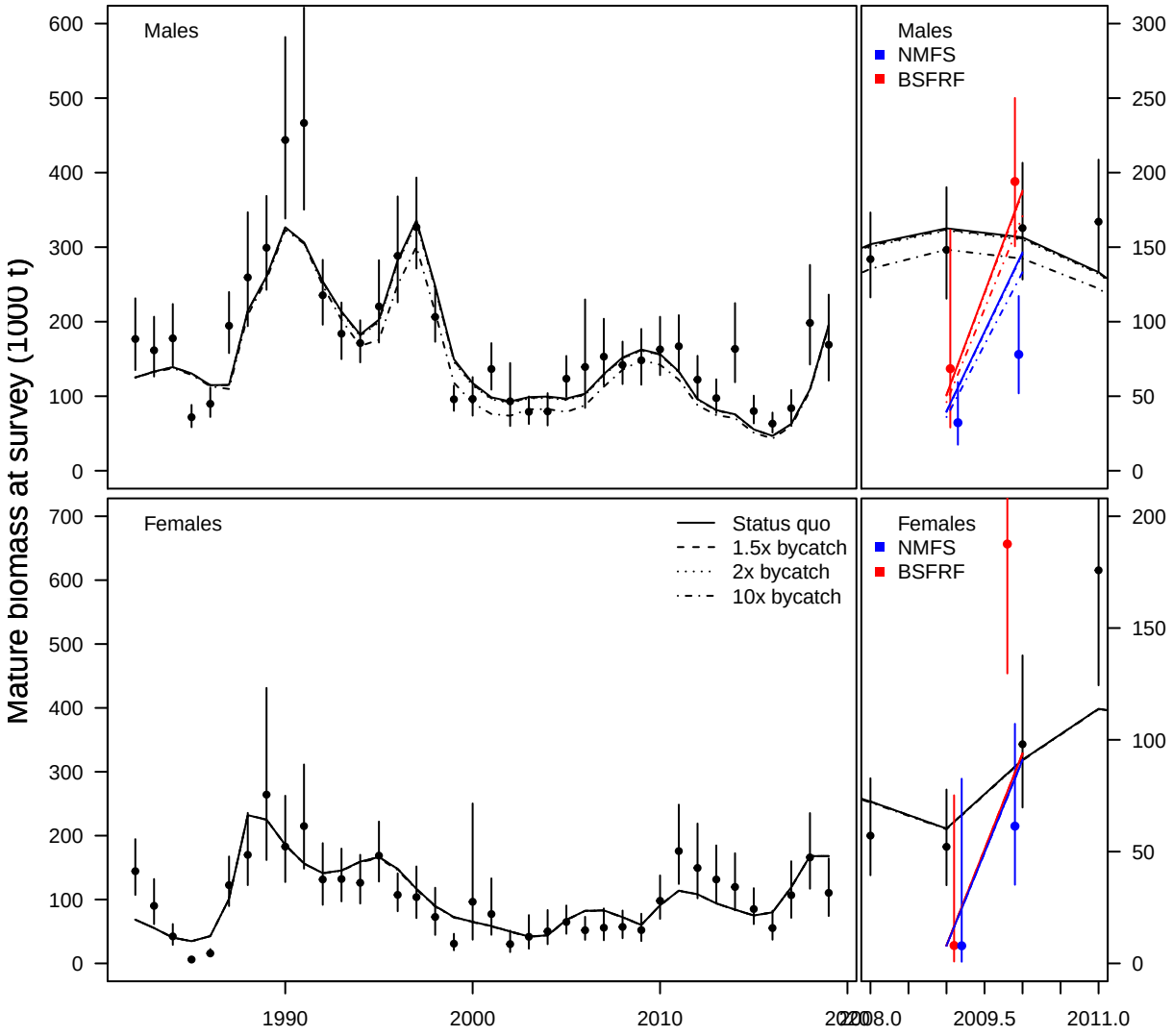

Figure 1: Model fits to the observed mature biomass at survey

Table 1: Changes in management quantities for each scenario considered. Reported management quantities are derived from maximum likelihood estimates.

Model	MMB	B35	F35	FOFL	OFL
Status quo	105.03	123.09	1.77	1.77	51.31
1.5x bycatch	104.89	123.10	1.76	1.76	51.34
2x bycatch	104.76	123.10	1.76	1.76	51.37
10x bycatch	102.61	123.10	1.69	1.69	51.45

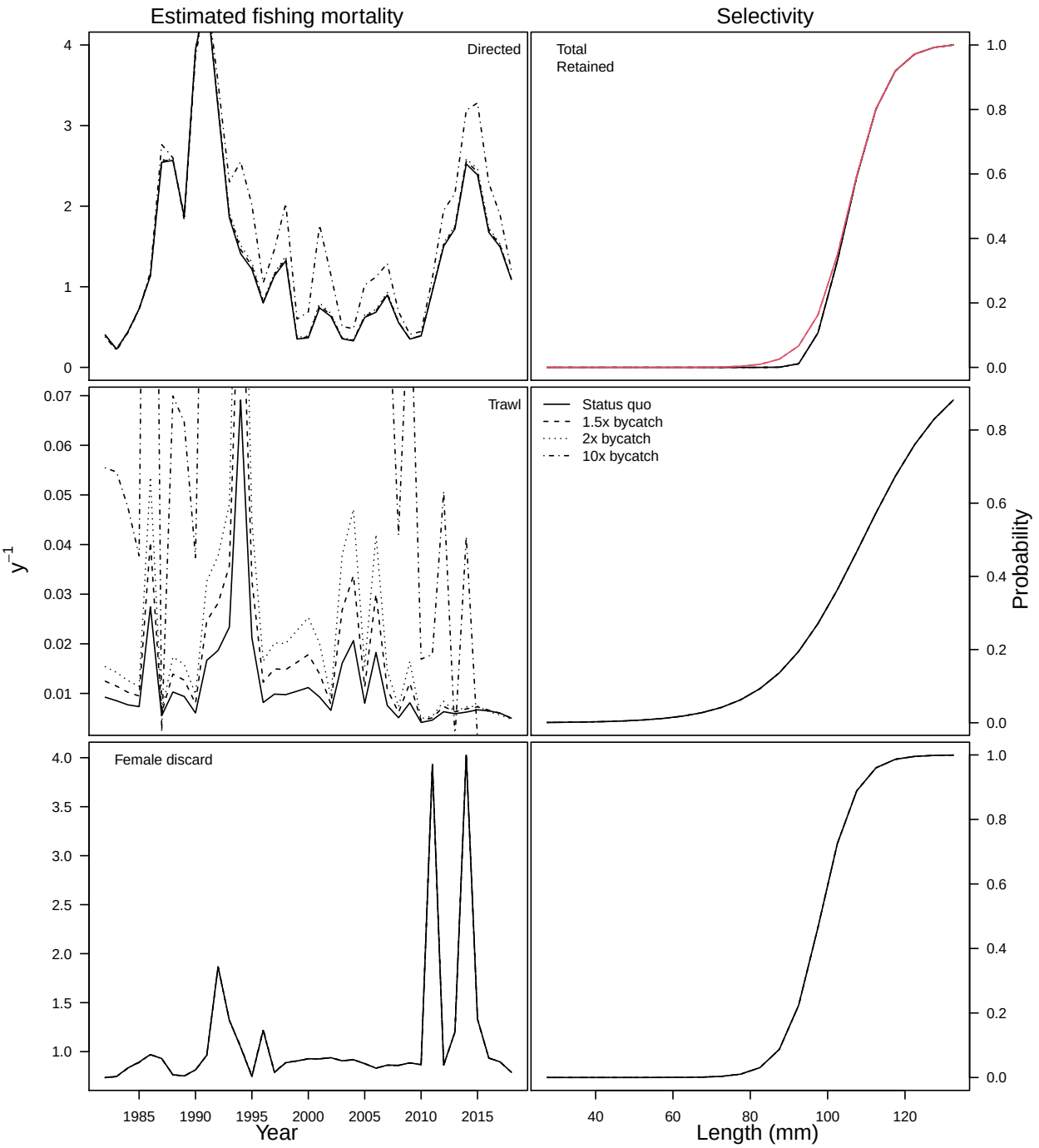

Figure 2: Model predicted fishing mortalities and selectivities for all sources of mortality