**Canada Atlantic cod (2J3KL) - longline/trawl/gillnet/hook & line FIP**

Action: Improve uncertainties in stock assessment.

The issue of uncertainty in catch estimates for both the commercial and recreational fisheries on the 2J3KL northern cod stock was identified in the initial 2011 MSC pre-assessment conducted for the fishery and was identified as a required corrective action in the FIP at its commencement in 2015 (i.e. pre-FP.org). Specifically, the defined action requires “Improve significant uncertainties that reduce confidence in the stock assessment” further noting that:

“The stock assessment tools used are subject to uncertainties, including uncertain catch estimates.  Improving catch estimates of all sources of fishing mortality will provide higher confidence in the stock assessment projections.”

After a modeling framework in 2015, the current Northern Cod Assessment Model (NCAM) was endorsed for use and was utilized in assessments starting in 2016. It is based on a state-space population dynamics model that integrates much of the existing information about the productivity of the stock. Key features of this model are that it provides annual estimates of natural mortality (M) and fishing mortality (F) rates along with measures of uncertainty; the model also estimates catch and requires an interval identifying a likely range of catch (upper and lower bounds). Cadigan (2015)[[1]](#footnote-1) noted of the NCAM model

*“State-space models have become the favored approach in modeling time varying ecological phenomena such as population dynamics (e.g. Schnute 1994; Gudmundsson 1994; Aanes 2007; Maunder and Deriso 2011; Nielsen and Berg 2014), animal movement (Patterson et al. 2008) and animal behavior (Morales et al. 2004). We include uncertainty about M in the process error component of the model. Extensive northern cod tagging information (see Brattey and Healey 2003, 2007; Brattey and Cadigan 2003; Myers et al. 1996) is included in the model to provide information about both fishing mortality rates (F) and M.”*

Brattey *et* al (2018)[[2]](#footnote-2) reported that the model integrates information from DFO RV autumn trawl surveys (1983-present), Sentinel fishery surveys (1995-present), inshore acoustic surveys (1995-2009) fishery catch age compositions, and partial fishery landings (1983--present), and tagging (1983-present). The DFO fall Research Vessel (RV) bottom trawl surveys occur over the continental shelf and shelf edge and cover most of the stock area of Northern cod. Indexed strata (strata that have been consistently fished in the survey; in the depth range 100-500 m in Divisions 2J3K and between 55-366 m in Division 3L) are used for the assessment of Northern cod. Age-disaggregated analysis of sentinel catch rate data was carried out and combined into a total for Divs 2J3KL (Mello (in prep) Standardized catch rates for 5.5 inch mesh gillnet (GN) increased from the early 2000s to 2014 but have since declined).

For Northern cod an extensive time-series of mark-recapture information is available which has the potential to provide valuable information about changes in F and M. The tagging data are in two parts. The earlier (i.e., pre-1997) tagging data are summarized in Taggart et al. (1995) and were analyzed by Myers et al. 1996, 1997. The more recent tagging data begin in 1997 and are reported in Brattey and Healey (2007) with the most recent tag return data (2007-14) provided directly by DFO (Brattey *et* al, 2018).

The tagging data comprise an extensive series of tagging experiments, where batches of cod are tagged and released in a specific geographic area and time. Tagged fish are subjected to initial tagging mortality due to the stress of capture and handling in the year of release. In addition, depending on the time of year fish were released and the timing of the fishery only a fraction of F and Z were applied in the year of release; the fraction of fishing that occurred was estimated from a table of monthly landings and this is an improvement over the procedure used in previous versions of NCAM (Brattey *et* al, 2018).

Information from recaptures of cod tagged in various regions of Divs. 2J3KL was used to provide an estimate of the magnitude of removals from the recreational fishery. Assuming the ratio of returned tags from recreational and commercial fisheries reflects the relative size of those two catches, information on the commercial catch and the ratios of the two types of tag returns can be used to calculate the recreational catch. Tag returns are adjusted by annual estimates of reporting rates (Brattey *et* al, 2018).

In summary, the NCAM model does take into account uncertainty in catches by using a catch-censored process of allowing catch to be estimated within upper and lower catch boundaries and using tagging estimates to parse removals into fishing mortality and natural mortality. In addition, while somewhat variable, tagging can be used to get an estimate of annual recreational fishery removals along with associated uncertainty (using ratios of recreational to commercial tag returns). It is expected that this will be published in an upcoming CSAS Research Document. (K. Dwyer, DFO Science. Pers. Comm., 12 May 2021).

1. *Cadigan, N. (2016). A state-space stock assessment model for northern cod, including under-reported catches and variable natural mortality rates. Canadian Journal of Fisheries and Aquatic Sciences, 73, 296-308.* [↑](#footnote-ref-1)
2. Brattey, J., Cadigan, N., Dwyer, K. S., Healey, B. P., Ings, D. W., Lee, E. M., Maddock Parsons, D., Morgan, M. J., Regular, P., Rideout, R. M. 2018. Assessment of the Northern Cod (*Gadus morhua*) stock in NAFO Divisions 2J3KL in 2016. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/018. v + 107p [↑](#footnote-ref-2)