Fisheries and Oceans Canada | Pêches et Océans Canada
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Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2022/043

ASSESSMENT OF 4VS AND 4W OFFSHORE WHELK (*BUCCINUM UNDATUM*) STOCK STATUS

Waved Whelk - Buccinum undatum (photo: DFO 2021)

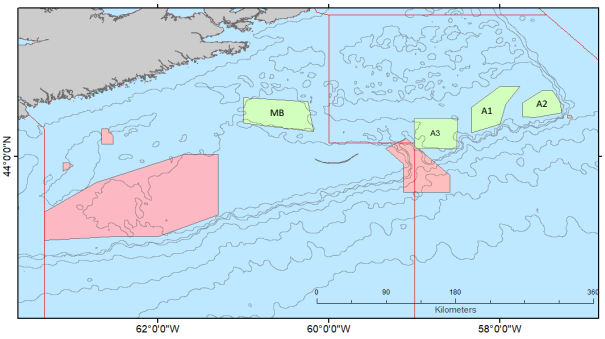

Figure 1. Offshore fishing of Whelk occurs in NAFO areas 4Vs and 4W outside of 50 nautical miles. Closed fishing areas are shaded in pink, and fishing areas in 4W (Middle Bank [MB]) and 4Vs (Areas 1–3) are shaded in green. The grey lines are depth contours and the red lines are the North Atlantic Fisheries Organization (NAFO) area boundaries.

Context:

*In 2021, DFO Resource Management requested advice from DFO Science on the stock status of Whelk in order to assess the viability of a commercial fishery in Offshore 4Vs and 4W. This advice will be used by Resource Management to decide on the status of the Offshore Whelk fishery, including whether to make a recommendation to move the fishery from exploratory to commercial status. This process can be used to provide information to develop an Integrated Fisheries Management Plan (IFMP), including the identification of fishing areas, appropriate removals, number of licence holders, and the use of indicators to monitor the stock. This is the first stock assessment of the Waved Whelk (*Buccinum undatum*) exploratory fishery in 4Vs and 4W Offshore. An assessment framework was completed on May 17–18, 2022, to identify indicators to monitor the Offshore Whelk fishery and develop reference points to assess stock status.*

This Science Advisory Report is from the June 14, 2022 regional peer review on Stock Assessment of Offshore Whelk in 4Vs and 4W. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Whelk populations differ in genetic structure and life-history traits over small spatial scales, making it important to consider sub-population structure when developing appropriate management areas to protect from local depletion of Whelk on the Scotian Shelf.
- The primary indicator of stock status is non-standardized catch-per-unit-effort (CPUE, kg/trap), which is used as a proxy for stock biomass.
- Limit Reference Points (LRPs) were established for all regularly fished areas (4W Middle Bank, 4Vs Area 1 and Area 2) and were estimated based on a proportion of B_0 proxy, which is the maximum mean annual CPUE value of the time series.
- In 4Vs Area 1, the mean annual CPUE estimates have declined since the high in 2017 of 17.41 kg/trap but increased again in 2021 to 15.84 kg/trap, just below the B_0 proxy, and remains above the LRP of 5.22 kg/trap.
- In 4Vs Area 2, mean annual CPUE estimates have declined from a maximum value of 16.98 kg/trap in 2018 to 13.25 kg/trap in 2020 and were above the LRP for the entire time series. There was no fishing in Area 2 in 2021.
- For 4W Middle Bank, the CPUE indicator in 2021 is consistent with the recent time series at 4.67 kg/trap and is above the LRP of 2.37 kg/trap.
- Secondary indicators of stock status were used to help identify changes that may occur in the primary indicator, including changes in catch, effort, and annual spatial distribution of catch rates. The use of additional secondary length-based indicators was approved for future monitoring, but these indicators require new data collection of length frequencies of the retained catch, and no data are available yet for reporting.
- In 2021, landings were from 4Vs Area 1 (329 mt), Area 3 (202 mt), and a new fishing area west of the boundaries of Area 1 (160 mt). In 4W, landings have declined from 211 mt in 2018 to 146 mt in 2021 and continue to be concentrated on the southern portion of Middle Bank.
- The detailed samples previously collected from industry included discarded catch, so are not representative of the retained catch and cannot be used to estimate length-based indicators. Therefore, new sampling protocols were developed to monitor the length frequencies of the catch so that this approved method can be applied in the future.
- Detailed sampling will continue to be important for new fishing areas to inform on maturity, growth, parasitism, and sex ratios based on the differences observed at small spatial scales.
- Since Whelk populations are susceptible to local depletion, it is suggested that Total Allowable Catch (TAC) limits be placed on specific fishing areas to encourage exploration outside of current fishing areas, and that indicators continue to be monitored as annual TAC limits increase slowly.

BACKGROUND

Species Biology

The waved or common Whelk (*Buccinum undatum;* herein referred to as Whelk) is a carnivorous gastropod widely distributed throughout subtidal waters in the North Atlantic (Mercier and Hamel 2008, Borsetti et al. 2018, Hollyman et al. 2018, Emmerson et al. 2020). Life-history characteristics of Whelk have been well studied in the current fishing areas on the

Scotian Shelf, based on detailed sampling conducted by industry throughout the exploratory Whelk fishery. Whelk populations differ in genetic structure and life-history traits (e.g., length distribution, growth, and size-at-maturity) over small spatial scales (Haig et al. 2015), making it important to consider sub-population structure when developing appropriate management areas to protect from local depletion of Whelk on the Scotian Shelf.

In 4Vs and 4W fishing areas, the lifespan of Whelk ranges from 12 to 16 years. The maximum legal size of the catch is 102–109 mm shell height with growth varying in each area (Barrett unpublished[1]). The timing of reproduction of Whelk is unknown on the Scotian Shelf but is likely comparable to the results of research conducted in the Gulf of St. Lawrence. Females gather in May to copulate and lay eggs two to three weeks later (Martel et al. 1986, Gendron 1992, DFO 1997). After five to eight months, fully developed juveniles emerge from the capsule (Martel et al. 1986, DFO 1997). Fecundity is greater in larger-sized Whelk (Thatje et al. 2019, McIntyre et al. 2015, Valentinsson 2002) and reproduction may not occur every year (Gendron 1992, Valentinsson 2002). The size at which 50% of Whelk are sexually mature (L_{50}) ranges from 45 to 64 mm for males and 53 to 65 mm for females in 4Vs (Ashfaq et al. 2019, Barrett unpublished[1]) and 63 to 65 mm for males and females, respectively, in 4W (Barrett unpublished[1]). On the Scotian Shelf, Whelk become mature at 5 to 6.5 years of age (Gendron 1992, Ashfaq et al. 2019, Barrett unpublished[1]).

Recruitment of Whelk is unknown, although based on the the absence of a larval phase and the limited mobility of adults, mixing with neighboring populations is likely restricted and reduces the likelihood of rapid re-colonization in exploited areas (Brulotte 2012). Recent studies on stock structure of Whelk in Atlantic Canada suggest multiple stocks along the Scotian Shelf, with populations in the Bay of Fundy and Georges Bank genetically distinct from Whelk sampled from Banquereau in 4Vs, Newfoundland, and the Magdalen Islands (DFO in preparation[2]). Samples were not collected from 4W, so the stock structure and extent of movement between 4Vs and 4W has not been determined.

Fishery

There are currently two active Offshore exploratory Whelk licence holders, one with access to 4Vs and 4W since 2010 and the second licence holder with access to 4W since 2012 (Figure 1).

The Offshore exploratory Whelk fishery occurs outside of 50 nautical miles in 4W and 4Vs, with the exclusion of several conservation areas (Figure 1). The typical fishing season occurs between June and December and, in addition to Waved Whelk, Stimpson's Whelk (*Colus stimpsoni*) and Moonsnail (*Euspira heros*) can be retained. The fishery uses conical traps with a rigid circular opening of ≤ 127 mm diameter to minimize bycatch. Trap numbers are limited to 1,500 per licence holder, and traps are typically deployed on a string approximately 20 fathoms from one another (Louisbourg Seafoods Ltd. 2017). The Whelk pots are fitted with a cotton twine section capable of degrading over time to act as an escape mechanism and to prevent ghost fishing if traps are lost (Louisbourg Seafoods Ltd. 2017, Wilcox in press[3]). The current

[1] Barrett, M. Unpublished. Framework review for the stock assessment of the Offshore Whelk (*Buccinum undatum*) in the 4Vs and 4W exploratory fishery. DFO Can. Sci. Advis. Sec. Res. Doc. Presented and reviewed in May 2022 at the Whelk Framework Review meeting.
[2] DFO. In preparation. Proceedings from the framework review for the stock assessment of the Offshore Whelk (*Buccinum undatum*) in the 4Vs and 4W exploratory fishery. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2022/nnn.
[3] Wilcox, M.A. In press. Development of a monitoring framework for the establishment of a commercial Whelk fishery in the Maritimes Region (4Vs and 4W). DFO Can. Sci. Advis. Sec. Res. Doc. Presented and reviewed in February 2020 at the Whelk Monitoring Framework meeting.

total allowable catch (TAC) is 500 mt in 4W (250 mt per licence holder) and 700 mt for the single licence holder in 4Vs, with a cap of 350 mt in Area 1.

ASSESSMENT

Stock Status Indicators

This stock assessment applies the selected methods and indicators reviewed at the 2022 assessment framework on Offshore Whelk in NAFO areas 4Vs and 4W (Barrett unpublished[1]). There are currently no fishery-independent surveys that can provide information on the abundance of Whelk in the Offshore Scotian Shelf; therefore, the assessment of Whelk is reliant on fishery-dependent data. All fishing activities are logged by trip using the Whelk Monitoring Document, which includes temporal and spatial fishing data, effort, landed catch, and incidental catch. Additional data are collected by Industry to determine size, sex, maturity, age, and parasitism from a subsample of unsorted catch. Fine-scale spatial differences in size and maturity of Whelk have been observed on the Scotian Shelf (Ashfaq et al. 2019) and, therefore, indicators of stock status are defined based on specific fishing areas (i.e., 4W Middle Bank [MB], 4Vs Area 1 and 4Vs Area 2).

Primary Indicator

The primary indicator of stock status is non-standardized catch-per-unit-effort (CPUE; kg/trap), which is used as a proxy for stock biomass. The analyses excluded CPUE estimates greater than 50 kg/trap (n = 9).

Virgin biomass (B_0) is the biomass of a stock that has not yet been fished, and a proportion of B_0 is commonly used as a candidate Limit Reference Point (LRP; e.g., Mace 1994, Sainsbury 2008). In data-limited fisheries, CPUE can be used as a proxy for biomass under the assumption that the two metrics are proportional to each other (DFO 2015). The maximum annual mean CPUE in the time series was used rather than the CPUE from the first year of fishing, based on the assumption that catch rates in early exploratory years of the fishery are not a true representation of potential catch rates (e.g., Kleisner et al. 2013). Based on the uncertainties regarding the stock dynamics (e.g., stock structure, resilience) and to provide a buffer from new fishing pressures and ecosystem changes, a more conservative 0.3 B_0 proxy was selected based on the Sainsbury (2008) guidance for setting reference points.

For 4Vs, the majority of fishing occurred in Area 1, with recent exploration extending to other fishing areas. For the 2011–2021 time series in 4Vs Area 1, the mean annual CPUE estimates have declined since the high in 2017 of 17.41 kg/trap but increased again in 2021 to 15.84 kg/trap, just below the B_0 proxy, and remains above the LRP of 5.22 kg/trap (Figure 2a). For the 2018–2020 time series in 4Vs Area 2, mean annual CPUE estimates have declined from a maximum value of 16.98 kg/trap in 2018 to 13.25 kg/trap in 2020, and were above the LRP for the entire time series (Figure 2b). There was no fishing in Area 2 in 2021. Fishing has occurred recently in 4Vs Area 3, but the collection of additional data would be required to set reference points.

For the 2014–2021 time series in 4W Middle Bank, the maximum mean annual CPUE (7.91 kg/trap) was observed in 2017 and was used as the proxy for B_0. Low CPUE values occurred during the first few years of exploration of the 4W area; however, CPUE stabilized from 2018 onward (Figure 2c). The CPUE indicator in 2021 is consistent with the recent time series at 4.67 kg/trap and is above the LRP of 2.37 kg/trap.

Secondary Indicators

Secondary indicators of stock status were used to help identify changes that may occur in the primary indicator, including changes in catch, effort, and annual spatial distribution of catch rates. The use of additional secondary length-based indicators was approved (Barrett unpublished[1]) for future monitoring, but these indicators require new data collection of length frequencies of the retained catch, and no data are available yet for reporting.

Landings and Effort

Landings of Whelk have generally increased in Offshore 4Vs since the beginning of the exploratory fishery in 2009 (Figure 3a). In 4W, landings were minimal until 2018. The highest total landings of Whelk were 690 mt in 4Vs in 2021, and 211 mt in 4W in 2018. In recent years, landings were spread out across Banquereau in 4Vs concentrating in three main areas (Area 1, Area 2, Area 3; Figure 1, Figure 3a). In 2021, landings were from 4Vs Area 1 (329 mt), Area 3 (202 mt), and a new fishing area west of the boundaries of Area 1 (160 mt) (Figure 3a, Figure 4). In 4W, landings have declined from 211 mt in 2018 to 146 mt in 2021 and continue to be concentrated on the southern portion of Middle Bank (Figure 1, Figure 3b). In 2021, landings were from the eastern portion of Middle Bank (127 mt), with 19 mt landed from an area south of Middle Bank (Figure 3b, Figure 4).

Effort in the Whelk fishery is based on the number of traps hauled. In general, effort has increased since 2015 in 4Vs with efforts doubling in 2018, driven by an increase in TAC from 350 to 700 mt and the addition of a third vessel to the Whelk fleet in 2019 (Figure 3a). Spatially, effort has expanded further east (Area 2) and west (Area 3) in recent years on Banquereau, with reduced effort in Area 1 in 2019 and 2020. In 2021, effort was concentrated on Areas 1 and 3 (Figure 4). In 4W, effort was minimal from 2012 to 2017 but increased substantially in 2018 with the addition of a second vessel to the fleet (Figure 3b). Effort in 4W has declined since 2019 as a result of the COVID-19 pandemic, reduced market demand, the use of only one fishing vessel, and a change in captain in 2021.

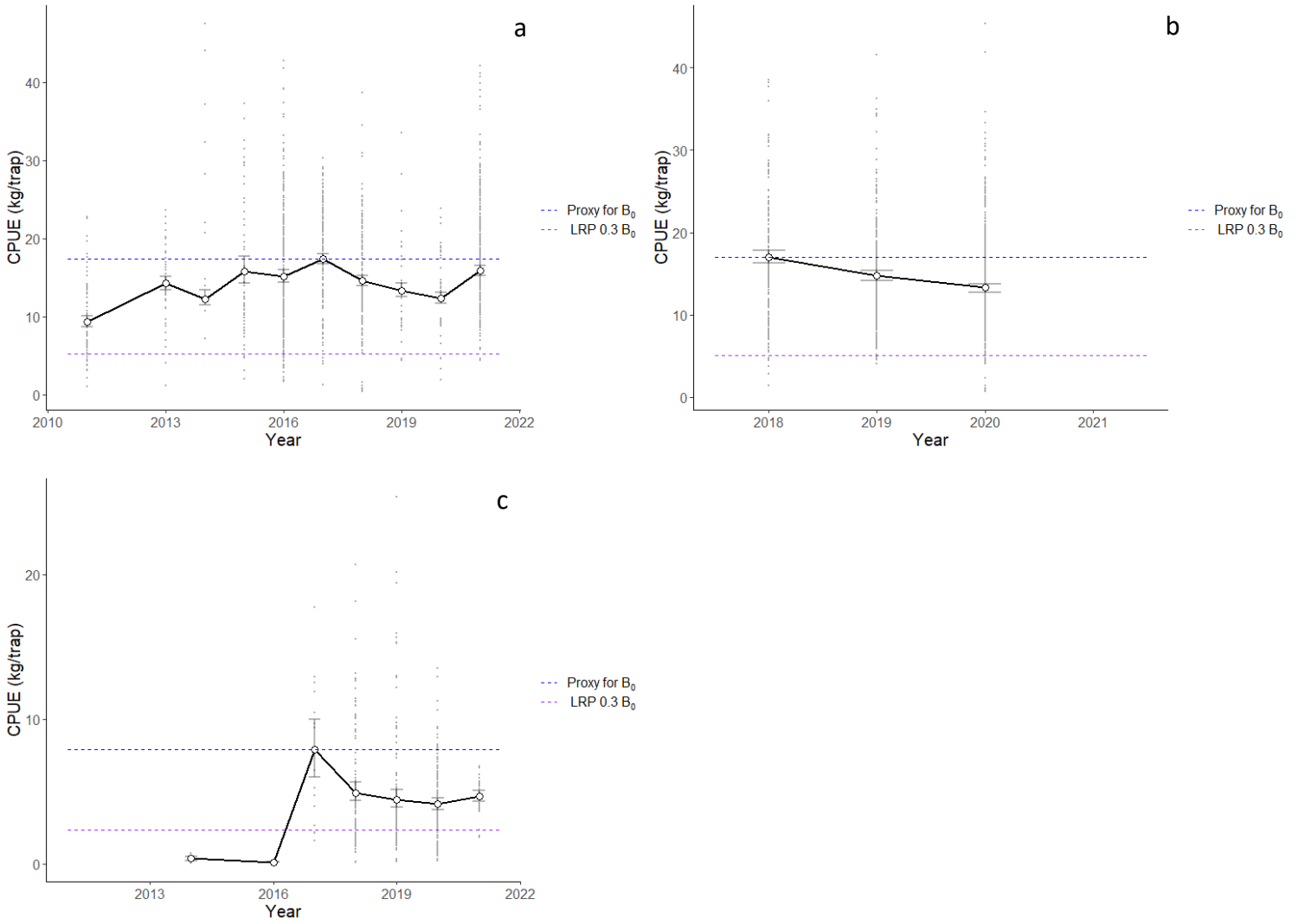

Figure 2. Mean catch-per-unit-effort (CPUE, kg/trap, open circles) for the Offshore Whelk fishery in a) 4Vs Area 1, b) 4Vs Area 2, and c) 4W Middle Bank. The error bars represents the 95% confidence intervals for the annual mean CPUE. The solid grey circles are the individual CPUE per set in each year. The blue line is a proxy for B_0 based on the maximum mean annual value in the time series and the purple line is the Limit Reference Point (LRP, 0.3 of the B_0 proxy).

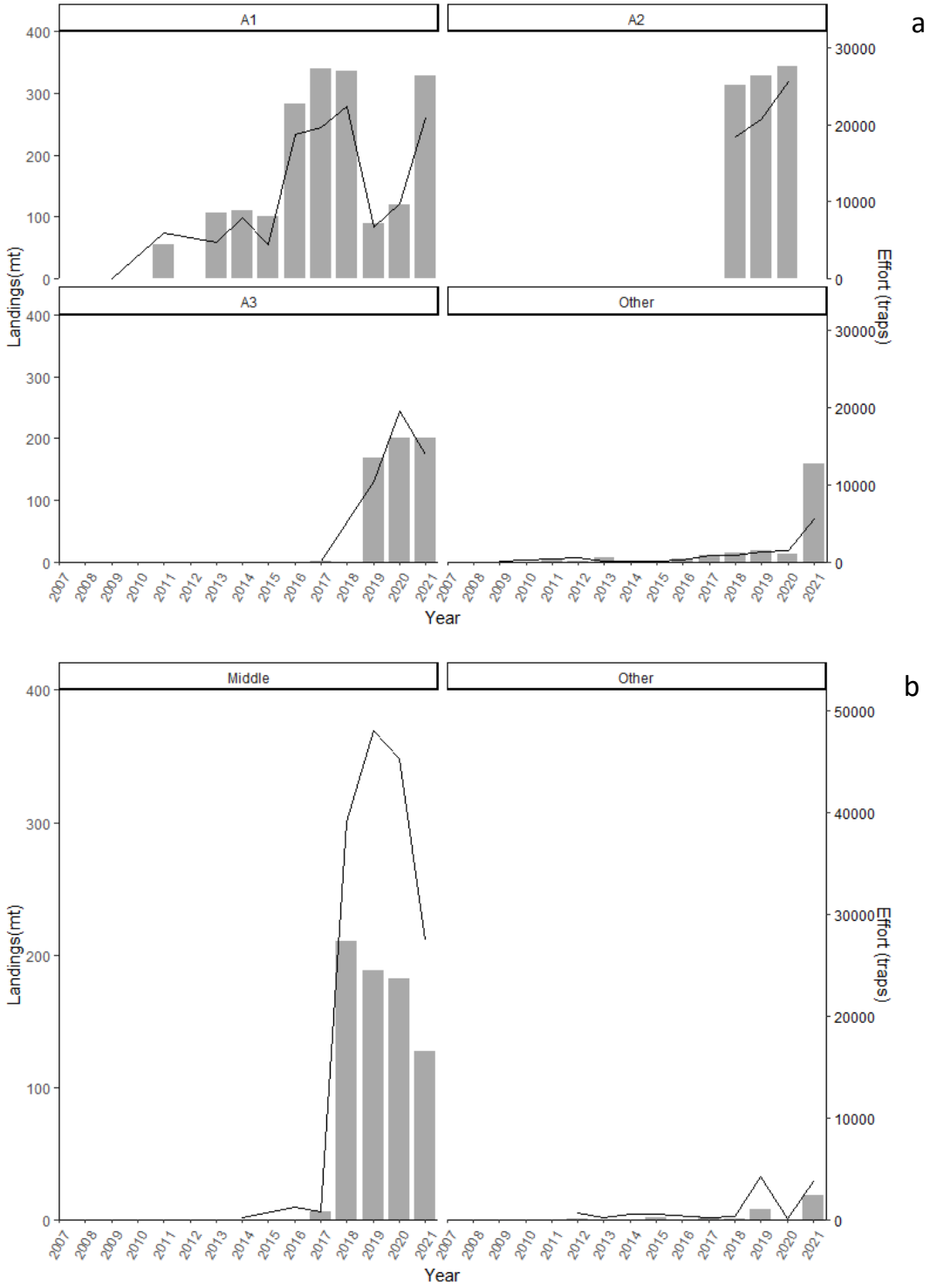

Figure 3. Exploratory Offshore Whelk fishery landings (mt; grey bars) and effort (number of traps hauled; black line) in a) 4Vs and b) 4W for each major fishing area. The "Other" category includes any fishing outside of the current defined fishing areas.

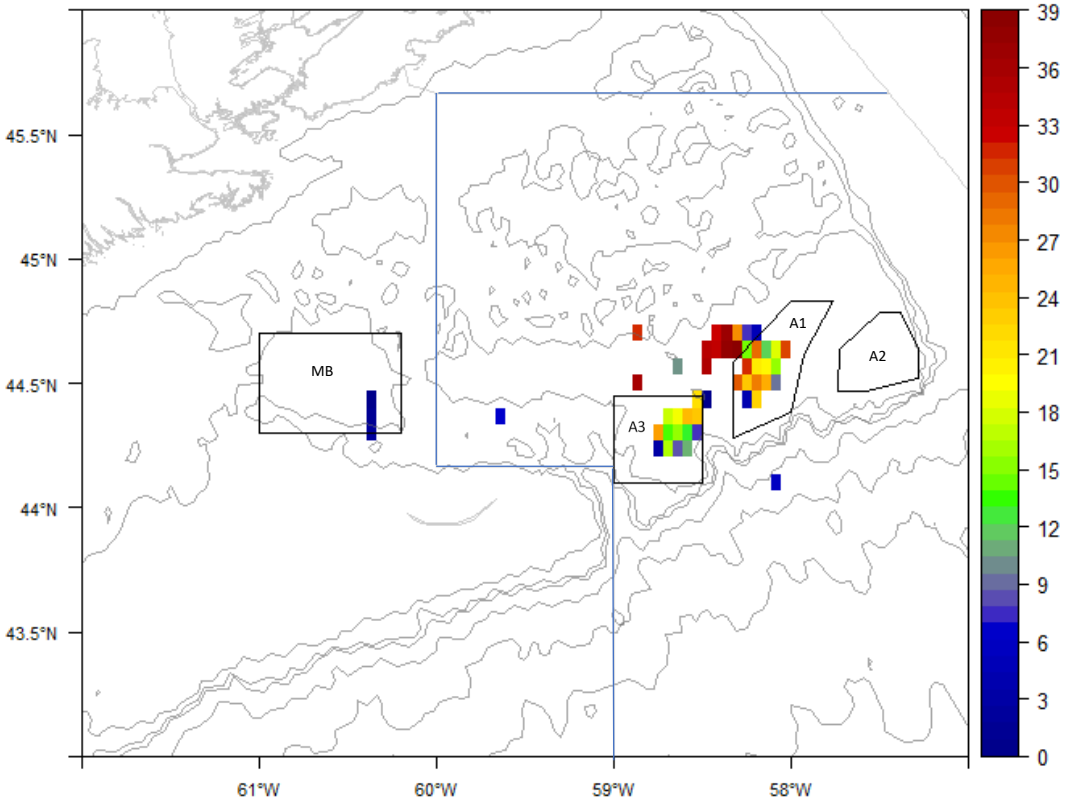

Figure 4. Spatial distribution of fishery mean catch-per-unit-effort (landings per trap haul using a 5 minute grid) of the exploratory Offshore Whelk fishery in 4W and 4Vs for the 2021 fishing season. The grey lines are depth contours and the blue lines are the NAFO area boundaries. The fishing areas in 4W (Middle Bank [MB]) and 4Vs (Areas 1–3) are outlined in black.

Length-based Indicators

For data-limited stocks, a representative sample of size-frequency data from the catch can be an easy and relatively inexpensive way to monitor a stock. The traffic light approach used by ICES (International Council for the Exploration of the Sea) for length-based indicators is a system of red and green lights to categorize multiple indicators in relation to desired stock status. This approach requires the length-at-maturity (L_{mat}), asymptotic length (L_{inf}), and catch-at-length by year. Length-based indicators can be calculated by sex and by year from length-frequency distributions that can then be compared to appropriate reference points related to conservation, optimal yield, and maximum sustainable yield (MSY) considerations (ICES 2018).

The detailed samples previously collected from industry included discarded catch, so are not representative of the retained catch and cannot be used to estimate length-based indicators. Therefore, new sampling protocols were developed to monitor the length frequencies of the catch so that this approved method can be applied in the future. The collection will require a subsample of the landed catch from each trip in a fishing season, which will then be separated out by fishing area for the analyses.

Sources of Uncertainty

Catch rate indicators that rely on commercial fishery data are commonly used to assess data-limited fisheries. Catch rates can be used as an indicator to monitor fishing areas; however,

concerns over the sole use of fishery-dependent data to monitor stock status are warranted. Fishery-dependent indicators such as CPUE may be impacted by changes in fishing behavior and experience, annual and seasonal variability, technological advances, and changes in environmental conditions (DFO 2009). For CPUE-based indicators, it is assumed that CPUE is proportional to the stock biomass; however, the link between CPUE and the stock biomass of Whelk is unknown. There is also a potential bias related to “hyperstability”, where CPUE remains stable while abundance is declining, leading to the overestimation of biomass and underestimation of fishing mortality (Quinn and Deriso 1999, Harley et al. 2001). This typically can occur when a fishery expands into new fishing areas or depths (Morato et al. 2006, Kleisner et al. 2013) and these new catches mask the overall decline in the population. Based on this, spatial management by fishing area may be essential for a commercial fishery to limit the impacts of hyperstability.

Catch rates have been presented as catch per trap hauled; however, the soak time of the trap can ultimately impact this indicator and was a consideration identified in the Whelk monitoring framework (DFO 2020). Studies on soak time of Whelk for 4Vs and 4W fishing areas indicate that a soak time of two to five days resulted in the highest CPUE (Louisbourg Seafoods Ltd 2019, Premium Seafoods 2019). This relationship was further explored in the assessment framework (Barrett unpublished[1]) to determine if CPUE should be adjusted for soak time; however, no clear relationship between CPUE and soak time was observed, mainly due to the high variability in the data. Soak time on a finer scale (e.g., hours instead of days) and for a longer time series may result in less variable data. Soak time should be recorded consistently and its influence on CPUE re-assessed in future monitoring of the fishery.

CONCLUSIONS

Whelk are vulnerable to over exploitation and local depletion leading to the loss of subpopulations. Recovery of those subpopulations is likely to be very slow based on the species. Management of Whelk fisheries is complicated by the fact that this species has a low fecundity, a lack of a planktonic larval phase with little or no migration between populations, slowing growth with increasing age, late maturation, and variation in life-history parameters for small spatial areas (Shelmerdine et al. 2007, Ashfaq et al. 2019).

A variety of indicators to monitor the 4Vs and 4W Whelk fisheries were explored in the assessment framework (Barrett unpublished[1]). Limit Reference Points were established for all regularly fished areas (4W Middle Bank, 4Vs Area 1 and Area 2) and were estimated based on a proportion of B_0 proxy, which is the maximum annual mean CPUE of the time series. The LRPs were set as 0.3 of the B_0 proxy for all areas to be more precautionary, based on the risk of local depletion of Whelk and stock uncertainties. Using the ICES length-based indicators was recommended in addition to the catch-based reference points to monitor multiple metrics of stock status based on length-frequency distributions but requires proper collection of data in order to be applied in future stock assessments.

Detailed sampling will continue to be important for new fishing areas to inform on maturity (length- and age-at-maturity), growth (lengths and age), parasitism (presence, absence, condition of the shell), and sex ratios based on the differences observed at small spatial scales. After several years of collection, this information can be used to develop indicators to monitor the stock and develop Limit Reference Points. Secondary indicators based on the length-based approach (ICES 2018) will require sampling of length frequencies for monitoring in each fishing area. A sub-sample of the landed catch (approximately 100 to 150 Whelk) should be retained from each trip, or from each fishing area on a single trip, and the shell height should be measured to the nearest 1 mm and co-ordinates recorded. Detailed sampling instructions and

datasheets will be provided to ensure consistent sampling across areas and for both licence holders.

As recommended in the initial monitoring framework (DFO 2020), data gaps still exist in the 4Vs and 4W Whelk fisheries. One major concern is the percentage of juveniles in the catch exceeding the 5% allowance described in the licence conditions. The length-based indicators can be used to monitor this moving forward. The minimum landing size is a measure implemented to allow for Whelk to reproduce before becoming vulnerable to the fishery. Length-frequency distributions of Whelk caught in the fishing gear prior to grading onboard suggest that 10–30% of these Whelk are juveniles, but the length-frequency distributions of landed Whelk are unknown (i.e., there are no data to indicate whether these juveniles are retained or discarded). It is recommended that the level of catch monitoring (e.g., at-sea observers, port sampling) be increased and effort be made to improve current sorting methods on board the vessel including a record of the number, or weight of small Whelk discarded at sea, or a modification to the current traps to reduce the retention of juveniles.

The analyses completed in this framework indicated that soak time was not a significant predictor of catch rate. Based on the literature and studies done by Industry, gear saturation is likely to occur after a period of time. Due to the variability in the data and the scale used for analyses (i.e., days), it would be beneficial to re-evaluate the impacts of soak time in a future framework when soak time is recorded at a finer time scale (e.g., hours) and by set level.

Large removals of Waved Whelk has the potential to shift species dominance from Waved Whelk to Stimpson's Whelk and should be monitored with an increase in fishing effort (Kenchington and Glass 1998, Wilcox in press[3]). Industry provided preliminary estimates on the proportion of the catch that contain Stimpson's Whelk (< 2%) but detailed trip level information is unavailable. In order to confirm that the proportion of the catch of Stimpson's Whelk is still low and is independent of location, additional sampling on a monthly basis should be completed over a fishing season to determine temporal changes in abundance and then on an annual basis to monitor any shift in species composition of the catch. This could be included during the regular detailed sampling completed by Industry or at the processing plant where the species are sorted for market.

Although fishery-dependent data can be used as a proxy for biomass, fishery-independent surveys are beneficial for the development of future assessment models and determining appropriate removal levels for a fishery. Further exploration of developing an abundance index from existing DFO led surveys (e.g., snow crab survey), or the development of an independent Whelk survey, would likely be necessary to estimate biomass more reliably. Potential methods for estimating biomass for the 4Vs and 4W fisheries were identified in Wilcox (in press[3]), which included the use of camera surveys and the development of a stratified dredge survey.

OTHER CONSIDERATIONS

In 4Vs, three main fishing areas with harvestable densities of Whelk were identified over multiple years, with catch rates consistent across areas. For 4W, only one main area on Middle Bank has been identified as having large aggregations of Whelk, while exploration outside of this area has yielded no Whelk or low quantities. Catch rates for 4W are much lower than for 4Vs even though effort remains similar. Whelk in 4W mature at a larger size than 4Vs, but they exhibit a similar growth rate. Based on length-frequency data, the average size of Whelk caught in 4W are larger than 4Vs and the estimated natural mortality based on life-history parameters is slightly higher. Current catches on 4W do not indicate that the stock is depleted below the LRP at the current fishing levels. However, caution should be warranted given the short time period

of harvesting in the area (2018+), the small spatial area containing Whelk, and the lower catch rates compared to Banquereau.

The timing of Whelk reproduction and mating duration is variable across its distribution (Heude-Berthelin et al. 2011). For Waved Whelk in the Gulf of St. Lawrence, copulation and egg laying begins in May and continues to July as water temperatures increase (Martel et al.1986, Himmelman and Hammel 1993). Based on the reproductive season, it is suggested from a conservation perspective that fishing be closed during egg laying to allow for females to reproduce prior to exploitation in the fishery. The timing of reproduction on the Offshore Scotian Shelf may differ from the Gulf of St. Lawrence and further research would be necessary to verify the proper timeframe for a fishery closure to protect reproductive females. This could be accomplished through monitoring monthly gonadosomatic index (e.g., gonad weight relative to body weight) and collecting specimens to determine stage of maturity using histology.

Without an appropriate biomass estimate from a fishery-independent survey, it is difficult to estimate an appropriate harvest rate to ensure a sustainable fishery. Based on the biology of the species, Whelk populations are believed to be closed systems with no larval transport and limited adult movement from other areas, which typically could buffer the population from removals. Therefore, any direct fishery removals would need to be monitored closely and re-assessed if necessary. Based on the current indicators, CPUE has fluctuated throughout the time series, which may be the result of annual variability in terms of fishing behaviour, or indicate that the current removals are already impacting the population. Since Whelk populations are susceptible to local depletion, it is suggested that TAC limits be placed on specific fishing areas to encourage exploration outside of current fishing areas, and that indicators continue to be monitored as annual TAC limits increase slowly.

It is recommended that a full assessment and review of reference points for the Maritimes Region Offshore Whelk Fishery be undertaken every five to seven years, or earlier if significant changes occur in indicator trends or fishing practices, or fishery-independent data become available. Otherwise, updates on the stock status of Whelk can be provided by DFO Science every two years pending approval of the Canadian Science Advisory Secretariat (CSAS) or as requested by DFO Resource Management.

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SOURCES OF INFORMATION

This Science Advisory Report is from the June 14, 2022, regional peer review on the Stock Assessment of Offshore Whelk in 4Vs and 4W. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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