Report from the Expert Panel (EP) on the evaluation of the ARK VRZ commitment during the 2019/20 fishing season

Summary and Recommendations

This is an update on the operation of and compliance with the ARK commitment during its second year of operation. The evaluation was completed by an expanded EP compared to 2019 (Appendix 1) and based on communication through video conferences and e-mails. The EP had access to fishery data up to the end of July 2020 and based its evaluation on this information combined with CCAMLR reports and recent publications related to the Antarctic ecosystem.

1. Response to RP-2019

The EP appreciates the feedback from the RP and considers this a stimulus toward improved focus and delivery of a research product that can ensure operational success of the VRZs. The work of the EP must be completed within a short timeframe. Time constraints for some EP members limit the working capacity of the EP. The EP regrets the late delivery of the final report of the RP and underlines the importance of having the response of relevance to EP work available soon after the RP meeting. This will allow the EP to use this response as a basis for early planning and work distribution for the coming year's report.

Last year's response from the RP has been thoroughly discussed and some new analysis carried out.

The EP is still concerned about the vague definition of "Best commercial effort" but as long as it is not used in a quantitative analysis it does not represent a pressing problem.

Punctual delivery of the full information from the fishery is the basis of the work of the EP and thus the EP repeats its concern from the 2019 EP report on this issue (see also subsection 2).

The ARK fleet represents a unique resource with respect to capacity and competence in marine operations in the Southern Ocean, including collecting material and data for scientific purposes. The EP is pleased to see that the industry makes their capacity and expertise available to researchers and concludes that there is a lot of valuable ongoing work. The demonstrated activities show both the willingness and the potential of ARK's fleet to contribute to scientific data collection. It is crucial that this work is adequately integrated with ongoing CCAMLR research and monitoring to ensure optimal utilisation of the available effort. Earlier experience underlines the importance of communication fora (workshops and meetings) between the industry and scientists to optimize the use of the ARK fleet as an efficient platform for data collection to inform CCAMLR based initiatives in developing EBFM.

The EP recommends -

a) The RP makes the relevant parts of the RP report available to the EP as soon as possible after the RP meetings
b) ARK takes note of the recommendation from 2019 of prompt delivery of data (see subsection 2)
c) A science – fishery communication forum is established to ensure that the ARK contribution is efficiently utilized.

2. Assess the compliance with the VRZs by ARK's fishing vessels

100% of the ARK fleet complied with the seasonal closure of VRZs during the current 2019/20 fishing season. All ARK vessels were concentrated in Subarea 48.2 during December 2019 through February 2020, in line with results from last year. Most of the fleet then moved to Subarea 48.1 during mid-March 2020.

After two years of operation of the VRZs the EP analysis identifies a clear change in the space/time distribution of fishing effort following the implementation of the VRZs. Catches have shifted to March-July in Subarea 48.1, with some VRZs (South Gerlache Strait and North Antarctic Peninsula) having ~0% of the catch during the last two fishing seasons. Furthermore, overall catches inside the VRZs have also decreased compared to previous years, although this change has varied among the VRZs: catches inside the South Shetland VRZ have remained similar (~10% on the annual catch); in the North Gerlache VRZ catches have decreased from ~23% before to 4% after 2019; finally, in the VRZs at the northern tip of the Antarctic Peninsula and in the South Gerlache Strait only small catches were obtained before 2019 (≤5%) and ~0% since the implementation of the ARK Commitment.

The EP regrets that for the second consecutive year, a significant number of ARK vessels did not provide the necessary haul-by-haul data to analyze the spatial and temporal catch distribution of the fleet. Only 7 out of 11 vessels delivered the fishery data required for analyzing the behaviour of the fleet. This affects the capability of the EP to provide reliable advice on, for example, "Best commercial effort" or on the effects of VRZs on fleet behaviour, both during and after the seasonal closure. The inability of ARK to deliver the data requested not only makes the work of the EP more challenging, but it may also create uncertainty about ARK's commitment as well as undermine the credibility of the VRZs initiative.

The EP recommends -

d) ARK works with its members to resolve the recurring difficulties in data delivery
e) ARK ensures prompt delivery of data in the future according to the ARK commitment

3. Provide an update on population trends of krill-dependent predators

Gentoo penguin populations remain stable or are increasing rapidly across Subarea 48.1. While Adélie penguin populations are generally decreasing throughout the Antarctic Peninsula, north of the Antarctic circle, there were few surveys performed in the 2019/2020 season to provide an update on the situation. However, the largest Adélie penguin colonies in Subarea 48.1, within the North Antarctic Peninsula VRZ, have very low overlap with current fishing distribution. Meanwhile, the chinstrap penguin population survey has demonstrated a clear decline across almost all of Subarea 48.1. The mechanism for the decline is not yet understood. Although some chinstrap colonies are stable or slightly increasing, the overall trend is a clear decline.

There is still a lack of standardized productivity indices (e.g., fledging success, breeding success, phenology, etc.) collected in a stratified fashion (i.e., designed with respect to proximity to fishing efforts). Such data would be beneficial for understanding the interannual impact of krill fishing on Pygoscelid penguins, and likely act as a more realistic feedback signal for ecosystem-based management. Due to a lack of systematic data collection, it is still unclear if the VRZs are having a positive effect on penguin population trends.

Photographic and molecular methods show that humpback whale populations around the Antarctic Peninsula are increasing. There is little information on the population trends of Antarctic minke whales in the region. Blue and fin whales, once numerous in the Bransfield and Gerlache Strait, where over 12,000 fin whales and 6,500 blue whales killed in the 1920s in commercial whaling enterprises[1]. Since then, only fin whales have shown signs of recovery in the region but they are still only a small fraction of their pre-exploitation levels. Blue whales have shown little sign of recovery so far. Despite the increase in humpback whale numbers, the overall biomass and numbers of baleen whales in the region is well below historic levels before commercial whaling.

Baleen whales remained at very low population levels compared to pre-commercial whaling estimates. Humpback whales are the species closest to recovery, yet their actual abundance in the Western Antarctic Peninsula area is still uncertain. Given the foraging strategy of baleen whales to target dense prey patches, and specifically the densest portions of these patches, direct competition with the krill fishery is likely.

Although the current VRZ scheme provides some protection to baleen whale feeding areas, it is imperative to obtain a better understanding of the habitat use, consumption rates, and characteristics of the krill patches targeted by baleen whales. Experimental research could help to determine the impacts of VRZs on whale body condition and whale reproductive rates. The EP considers identifying critical areas and periods of the year when baleen whale feeding overlaps with the krill fishery necessary and emphasizes that this issue might require attention and potential support by ARK in the coming years.

The EP recommends -

f) ARK works with relevant data holders to support collection of stratified data in the form of penguin productivity indices at key sites throughout Subarea 48.1.

g) ARK supports a systematic collection of data on whale – fishery interactions during fishing operations.

4. Update status on monitoring surveys and on krill population status

Due to the limited activity in CCAMLR Working Groups this year there was no new information on this issue available to the EP. The EP assumes that the local area surveys conducted by China (Subarea 48.1), Norway (Subarea 48.2) and UK (Subarea 48.3) have taken place but without a CCAMLR evaluation of the results that supports an update of the population status of krill.

[1] Kemp S and AG Bennett. 1932. On the distribution and movements of whales on the South Georgia and South Shetland whaling grounds. In: Discovery Reports, VI, pp. 165–190.

Based on available published information on trends and variability in the krill stock (as recorded in previous scientific surveys) the EP finds no reason to expect a change in the 2020 situation compared to 2019 beyond the naturally high inter-annual variability.

The EP has no particular recommendation under this item.

5. Review the required changes to modify the seasonal VRZs into a year-round protection measure and determine the size of such protection

The EP discussed the potential risks and benefits of a year-round protection and how this might vary with the spatial extent of the VRZs. The benefits include protection of species or ecological processes that fall within the VRZs. The risks are associated with relocation and potential concentration of fishing effort elsewhere.

The EP acknowledges the request by the RP to identify "*which areas could be closed that from a scientific point of view has the greatest ecosystem benefit and the lesser adverse effect on the fishery*" but notes that there will be no ecological benefit of protection if the influencer (fishery) is not affected. Similarly, the greatest ecosystem benefits are unlikely to coincide with the least effect on the fishery. The EP has considered where year-round closure within the VRZs might be beneficial in general based on current evidence and has proposed an approach to increase information with minimal disruption to the fishery during the information gathering phase.

Based on recent results, there might be a need for stronger protections of chinstrap penguins in terms of year-round protection. Although there are insufficient data available to assess the impact of fishing on penguin populations, penguin productivity might be negatively impacted, particularly in warm years. Further to this, new findings demonstrate that the maximum foraging range of penguins is dependent on colony size, and this could impact efficiency of the present VRZs regime. Large colonies might require protection up to 60km around colonies which is not accomplished with the current size of the VRZs. Although changing the ARK commitment and the VRZ regime is beyond the mandate of the EP, the panel notes the potential need to extend the VRZs.

On the other hand, published analyses of concurrent overlap of penguin tracking data and fisheries operations[2] demonstrate species-specific patterns of overlap with the fishery. These patterns indicate that Gentoo penguins have the greatest overlap with the fishery during winter, when the fishery is most intensive in the Bransfield Strait. By contrast, adult chinstrap and Adélie penguins migrate off the Bransfield Strait during winter. More detailed exploration of species-specific patterns of fishery overlap is required.

Based on the uncertainty associated with year-round closure the EP suggests an experimental approach where a certain fraction of the chinstrap colonies is protected, leaving the rest exposed[3]. An experimental approach requires adequate monitoring in the protected/exposed areas to support analyses of the fisheries impact. Taking into consideration the request of minimum impact on fishing

[2] Hinke JT, Cossio AM, Goebel ME, Reiss CS, Trivelpiece WZ and GM Watters. 2017. Identifying Risk: Concurrent Overlap of the Antarctic Krill Fishery with Krill-Dependent Predators in the Scotia Sea. PLoS ONE 12(1):e0170132, 2017.
[3] Trathan PN and SL Hill. 2016. The importance of krill predation in the Southern Ocean. In Biology and ecology of Antarctic krill (pp. 321-350). Springer, Cham.

operations the EP suggests that the northern part of South Shetland Islands VRZ could be closed year-round (Figure 1).

From the fishery perspective, closing the VRZ located at the South Gerlache Strait (with a predominance of Gentoo penguins) and at the northern tip of the Antarctic Peninsula (where the largest colonies of Adélie penguins are located) will have the least impact on catches and thus, lower risk of effort displacement (Figure 1; Table 1).

Humpback whales in particular, make extensive use of the Western Antarctic Peninsula area for foraging during the Austral summer, fall and even winter months. Although baleen whales tend to distribute broadly across the continental shelf during the summer months, the Gerlache and Bransfield Straits and associated bays are continuously used by whales for foraging from January to June, preferring mainly coastal waters during April-June.

Currently there is not comprehensive data available to determine how krill fishing impacts the foraging success and population dynamics of baleen whales. Nonetheless, existing VRZs do not adequately span over the temporal period of the feeding season for whales, particularly from March-June.

The Gerlache Strait area is ecologically important and the need for protection in this area requires further attention in future deliberations of the EP.

The EP recommends -

h) An experimental year-round closure of the VRZ around King George and Nelson Islands (the northeastern South Shetland Islands, Figure 1) and the establishment of an expert group to design appropriate data gathering and analysis.

i) ARK should consider ways to support the analysis of the relationship between maximum foraging range and colony size in chinstrap penguins, and the interaction between fishing and humpback whale foraging success.

6. Harmonize current VRZs with other initiatives

Due to the lack of new information the EP has not thoroughly discussed this issue in 2020. The impact of Covid-19 has limited the discussions of the various initiatives as is apparent from the cancelled in person CCAMLR Working Group meetings and the restricted agenda of the online discussions. The EP is aware of the progress made by the various initiatives (D1MPA, FBM and risk assessment) and foresees substantial new information becoming available next year.

There remains a need for better coordination between the various fisheries management and conservation efforts in the Antarctic Peninsula region. A key priority should be to clarify the objectives of each of them and to identify any additional work that is necessary to combine these approaches. It is the intention of the EP to interact with the various groups working on these initiatives and ensure that the most relevant information is included in the EP's analysis and discussion.

The EP recommends -

j) The RP prioritizes this issue in the 2021 report.

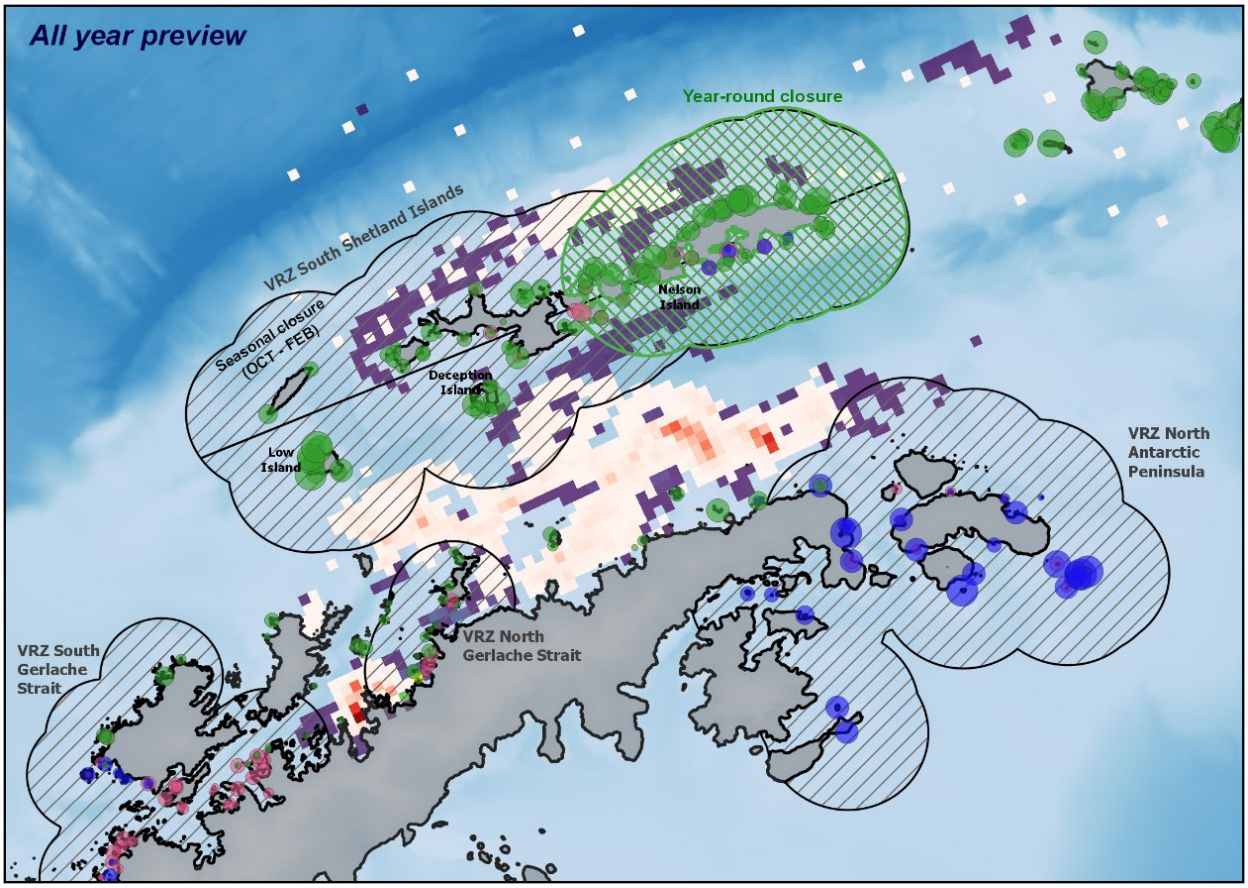

Figure 1. Northern Antarctic Peninsula and the South Shetland Islands, depicting current seasonal VRZs (black bubbles with gray dashes) and proposed area for experimental year-round closure (green bubble with green dashes). The new year-round protection VRZ covers 40km around Chinstrap penguin colonies located at King George and Nelson Islands (northeast South Shetland Islands). Penguin colonies indicated by species and abundance (Source: MAPPPD, April 2019). Distribution of accumulated catch distribution during winter (March-July) for two periods: 2015-2018 (before VRZ) and 2019-2020 (with VRZs in place) (Source: ARK).

Table 1. Proportion of catches obtained inside current and proposed VRZ limits (spatial and temporal), based on ARK vessels before (2013-2018) and after (2019-2020) the establishment of the ARK Commitment.

SCENARIOS	**2013-2018*** % catches (range) inside VRZs	**2019-2020** % catches (range) inside VRZs
Scenario 1. Current VRZs Closure: October-February	8.7% (0% - 21.0%)	0% (0% – 0%)
VRZ South Shetland Islands	3.4% (0% - 17.0%)	0% (0% – 0%)
VRZ North Antarctic Peninsula	0.0% (0% - 0.1%)	0% (0% – 0%)
VRZ North Gerlache Strait	4.9% (0% - 11.1%)	0% (0% – 0%)
VRZ South Gerlache Strait	0.4% (0% - 1.4%)	0% (0% – 0%)
Scenario 2. Scenario 1 + Year-round closure of VRZ NE South Shetland Islands (King George and Nelson Islands)	10.9% (6.1% - 21.0%)	1.3% (0% – 2.5%)
Extra displacement due to adding VRZ NE South Shetland Island (Mach-September)	2.2% (0% - 7.2%)	1.3% (0.0% - 2.5%)

*We used the period 2013-2018 for historical distribution, as catches in 2011 & 2012 were significant smaller than other years.

7. Ecosystem based framework for evaluation

Ecosystem based fisheries management (EBFM) provides a holistic way of managing fisheries to balance multiple objectives. Evaluating the performance of any management measure against objectives requires more specific information on the performance variables and their associated reference points (e.g. targets or limits) as well as data on the status of these variables. CCAMLR has defined reference points for the status of the krill stock, but neither CCAMLR nor the proponents of the VRZs have defined reference points for performance variables related to other ecosystem components (e.g. krill dependent predators). Working in that direction requires detailed ecosystem information and well-designed monitoring. The match between current monitoring and explicit objectives has not been formally evaluated.

ARK fishing companies have demonstrated willingness and competence to provide key data on krill as well as information on other components of the ecosystem. CCAMLR scientists are presently working on multiple initiatives in support of EBFM (D1MPA, FBM and risk assessment). The EP aims to interact with scientists behind these initiatives to learn about the status and expected outcomes (see subsection 6). This will help the EP to incorporate the present status in its considerations and to evaluate the potential benefit of data collected by ARK in the development and implementation of these initiatives.

The EP recommends -

k) ARK interacts with scientists through the communication forum (recommendation *c*) to prepare a list of variables and associated instrumentation that presently or in the future could be accommodated to support EBFM data collection

l) ARK similarly evaluates how the organisation can most efficiently organize their data collection in support of the various CCAMLR based fisheries management initiatives (D1MPA, FBM and risk assessment).

The 2020 analysis and evaluation

I. Background

In July 2018, ARK (the Association of Responsible Krill harvesting companies) launched a set of voluntary measures, known as ARK's Commitment, which were proposed to improve the long-term sustainability of the krill fishery. The Commitment was initiated with support from Greenpeace, WWF and The Pew Charitable Trusts as a precautionary action while CCAMLR develops spatial management of the krill fishery in Area 48. The Commitment, which took the form of Voluntary Restriction Zones (VRZs), provides seasonal protection of up to 40 km from penguin colonies in Subarea 48.1 during the penguin breeding season (Figure 2).

The 2018/19 fishing season marked the beginning of the implementation of the VRZ, which was reviewed by the Expert Panel 2019 (EP-2019). A series of recommendations for the second year of implementation of the VRZ were proposed to the Review Panel 2019 (RP-2019).

Due to the disruption associated with the Covid-19 pandemic in 2020, limited new research information was available to the EP. With this limitation considered, the EP has updated its report from 2019 and discussed compliance in the 2019/20 fishery and available assessments of predators and prey. Furthermore, the EP has discussed progress in relevant research and updated recommendations to the RP accordingly.

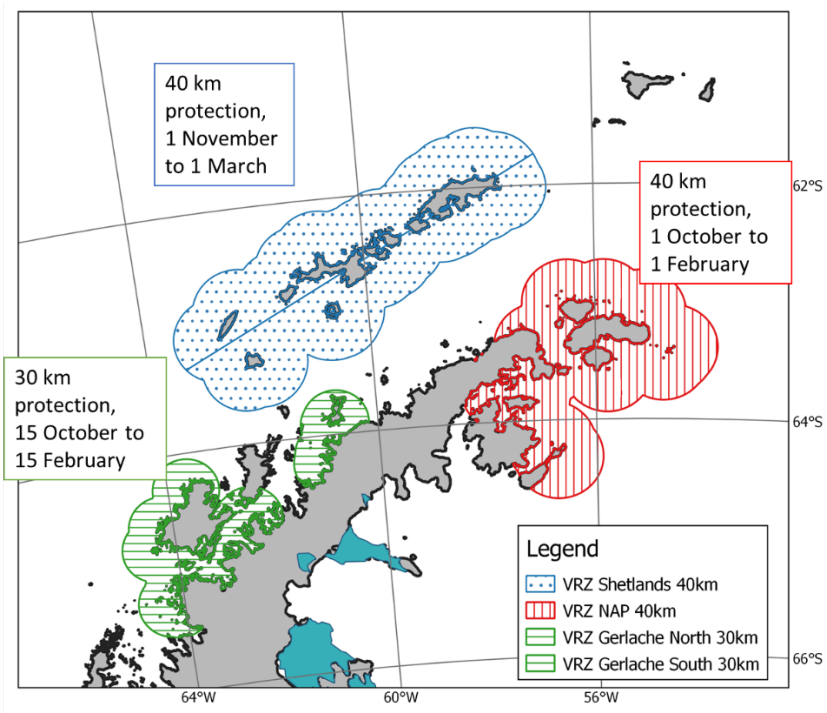

Figure 2. Map depicting the size and duration of the seasonal closure of Voluntary Restricted Zones (VRZs) around the South Shetland Islands, the northern tip of the Antarctic Peninsula (NAP), and northern and southern areas of the Gerlache Strait.

II. Objectives of the Expert Panel

1. Assess the compliance with the Voluntary Restricted Zones (VRZ) by ARK's fishing vessels, and the principle of "best commercial effort" outside of the seasonal measure.
2. Provide an update on penguin population trends in the areas subject to the ARK's Commitment.
3. Review the required changes to modify the seasonal VRZs into a year-round protection measure and the size of such protection.
4. Harmonize current voluntary measures with other initiatives discussed in CCAMLR (i.e., D1MPA, FBM, CM 51-07).
5. Provide advice on complementary, operable industry measures to provide adequate ecosystem protection while waiting for equivalent CCAMLR regulations to be adopted.

The EP further considered the explicit request from the Review Panel: Analyze fishing displacement since the implementation of the VRZ in relation to historical distribution and consider from a scientific point of view, which areas among the VRZs could be permanently closed with the most significant ecosystem benefit and the least adverse effect on the fishery.

III. Working mode of the Expert Panel

The expanded EP-2020 (Appendix 1) met from mid-July to late September 2020, through several video conferences for coordinating the work and discuss key elements of the report. To ensure that all members had the same basis for the discussions, a cloud folder was continuously updated with relevant papers, presentations and drafts of the progressing report. Key elements of the report were covered by the relevant experts and included as Appendices of this report. A total of 5 e-meetings facilitated discussions of all elements of the report, with a focus on this year's advice.

The RP-2019 requested expanding the expertise of the EP by incorporating experts on ecosystem-based management and whale ecology. After consultation with members of the EP and RP, Anna Rindorf and Ari Friedlander were approached, and they kindly agreed to serve the panel. With these new additions, the EP-2020 operated with seven Members, plus the Secretary (Appendix 1).

IV. RP response to EP-2019 report

EP-2019 recommended replacing the term "best commercial effort" with a quantitative measure or removing it from the ToR if this is not possible. The RP-2019 considered this advice reasonable. The RP decided, nevertheless, to maintain the concept but asked ARK to clearly define "best commercial effort" which now is found in Appendix 2.

The EP acknowledges the more precise new version of the concept but underlines the difficulty of using this definition quantitatively. In any case, the practical application of this concept has not been undertaken in the evaluation and advice of the EP.

Second, the EP-2019 recommended that ARK ensures punctual data delivery for each future annual evaluation. The RP-2019 echoed this advice. As seen in the next section, the same issue surfaces this year, underpinning the need for an adequate response from some ARK members.

Third, the EP-2019 identified and recommended additional requirements for the operation of the VRZs, including (i) monitoring of penguin colonies, (ii) analysis of the potential impacts from fishing effort concentration/high local harvest rate (the relationship between catch and biomass in a given area), (iii) understanding the environmental conditions in fishing hotspots.

In response, ARK provided a list of ongoing research activities supported by the fleet. The EP underlines the importance of ARK supporting science by putting field competence and capacity to their disposition and thus ensuring a better capability to solve pressing issues associated with the management of the krill fishery. In the past, ARK has communicated with scientists through workshops and informal meetings. Such communications fora have increased trust and mutual understanding and could serve as a model for the further development of the ARK fleet as an efficient platform for data collection. It also would ensure that ARK efforts are presented to CCAMLR Working Groups and fully utilized in ongoing and planned projects among CCAMLR scientists.

Further, the RP requested an analysis demonstrating the impacts of the VRZs on the spatial and temporal distribution of fishing effort (before and after introducing VRZs). The response to this request is found in chapter V.1.

Finally, the RP requested specifically "Review the required changes to modify the seasonal VRZs into a year-round protection measure and the size of such protection." To the understanding of the EP, the RP is requesting a scientifically based recommendation of what parts of the VRZ scheme could be permanently closed with the least negative impact on the fishery. The EP has neither the appropriate data available nor the capacity to conduct such an extensive analysis. Thus, the discussions of the EP are based on published information as well as on analyses under the various sections below. Final recommendations are given under "Evaluation and advice."

V. Results and updated analysis from the 2019/20 fishing season

V.1. Krill fleet spatial pattern during the current season

A total of twelve vessels participated in the krill fishing season 2019/20, eleven of which are affiliated to ARK. The EP reviewed the distribution of the fleet during this season using independent maps generated through the GlobalFishingWatch.org platform. The platform provided the track for 9 out of the 11 ARK vessels fishing for krill during the 2019/20 season. Spatial distributions for the other two vessels were obtained either through haul-by-haul locations or ARGOS maps provided by each company.

The combined distribution of fishing data and vessel tracks shows that all eleven ARK vessels remained outside the VRZs during the voluntary seasonal closure, as per ARK's Commitment. All ARK vessels concentrated in Subarea 48.2 during that period (December 2019 -February 2020), in line with results from last year. Most of the fleet then moved to Subarea 48.1 during mid-March 2020.

ARK members were requested to provide haul-by-haul data to analyze (i) vessel and catch distribution during the 2019-20 fishing season and (ii) impact of VRZ on the overall distribution of catches, compared with historical data. Seven out of the eleven ARK vessels (representing four out of seven companies) participating in the krill fishery submitted haul-by-haul data. The other three companies, all based in China, had expressed internal confidentiality issues regarding the release of fishing data.

Fishing displacement following the implementation of VRZs

The impact of the VRZs on the effort distribution of the ARK fleet was analyzed by comparing available catch distribution data from the last two fishing seasons (with VRZs in place) with the historical (2010-2018) catch distribution from ARK vessels (7 vessels, representing ~66% of the fleet). Overall, the introduction of the VRZs has produced a reduction of catches in Subarea 48.1 during the Austral summer (December-February), from ~17% to 1.5% of the annual quota, with a concomitant increase of catches during the Austral fall and winter (March-July), from 85% before 2018, to ~99% since the 2018/19 season. However, even during the Austral fall and winter, catches since December 2018 remained mainly outside the VRZs: 85% outside vs. 14% inside, compared to 57% vs. 27.5%, respectively, before the implementation of the VRZ. This effect is not equal across the current VRZs, with some VRZs maintaining a similar contribution to the overall catch in Subarea 48.1 as before its implementation. The VRZ around the South Shetland Islands contributed similarly to the annual catch, with 10.7% and 10.3%, before and after the fishing season 2019 (when the VRZs were established), respectively. At the other extreme, the contribution of the VRZ around the northern tip of the Antarctic Peninsula remained marginal to the overall catch in the Subarea, with 1.2% and 0.03% before and after 2019, respectively. The VRZs that experienced a greater change are located at the north and south ends of the Gerlache Strait; the North Gerlarche Strait VRZ decreased from 22.9% to 4.0%, on an annual basis, before and after 2019, respectively, while the South Gerlarche Strait VRZ decreased from 4,8% before 2019, to 0.0% since the implementation of the VRZs.

V.2. Penguin population trends

The largest colonies of Adélie penguins are found in the northern VRZ region, with a total population of approximately 1.2 million breeding pairs. The largest Adélie penguin colonies are found in the Danger Islands, with colonies numbering up to 250,000 breeding pairs. The largest chinstrap penguin colonies are spread throughout the South Shetland Islands. Harmony point on Nelson island is home to an estimated 90,000 breeding pairs, though in the 1980s, it was estimated that over 300,000 pairs nested here. Colonies on Low island were in the order of > 200,000 breeding pairs in the 1980s, but have since declined to approximately 10 – 30,000 pairs. Deception Island (i.e., the Baily Head colony) was estimated to have 125,000 breeding pairs in the 1980s but has now declined to approximately 39,000 breeding pairs. Due to a lack of long-term monitoring at these sites, it is impossible to determine if these declines were linear (i.e., started in the 1980s and progressed until now), or were more pronounced as fishing pressures increased.

Recent publications on penguin population status in Subarea 48.1 indicate a similar trend as presented last year. New population estimates for Adélie and Chinstrap penguins at King George Island (KGI, in the South Shetland Islands, SSI) depict a 68% decline since 1980/01. By contrast, Gentoo populations at King Stranger Point (also at KGI) indicate a 74% increase since 2000/01.

A recent survey at Elephant and South Shetland Islands, supported by Greenpeace and Oceanites and funded by PEW, indicates a ~56% decline of Chinstrap penguins since 1970/71. The survey also found an increase in Gentoo penguins in the same area.

The causes of these trends are not clear. A recent study from two sites on the South Shetland Islands suggested that an index of penguin performance decreased in years where krill catch rates were > 0.1. This work also suggested that the impact of krill fishing was similar to that of pressure from environmental change as measured by the Oceanic Nino Index[4]. This study was unique from others in that it made use of an index of productivity rather than straight measures such as breeding success or the total number of breeding pairs; the study focuses on chinstrap penguins. By contrast, other modelling efforts for relating Pygoscelid penguin species trends with environmental mechanisms had been inconclusive.

Overall, these studies confirm that for Gentoo penguins, breeding success remained constant throughout the study period, at a time when fishing pressure was increasing throughout Subarea 48.1. Long-term Adélie penguin population dynamics are predicted by changes in sea ice concentration but are not explaining interannual variation. Chinstrap penguins continue declining, including at Elephant Island, where fishing efforts have been somewhat limited in recent years compared to the Bransfield Strait or north-western side of King George Island.

A recent study provided insights on Pygoscelid penguins population structure[5]. First, it seems that penguin colonies act like clusters and that population trends and breeding success are likely to be very similar between nearby colonies. Second, the maximum foraging range of penguins seems positively correlated with cluster size. For Adélie penguins, the study found that they forage as far out as 180km in very large colonies (> 140,000 pairs), but as close as just a few kilometers with colonies < 200 individuals; similarly, for chinstrap penguin colonies >13,000 breeding pairs, foraging range is ~60km. These findings suggest that currently, VRZs are not providing adequate protection for large colonies throughout the breeding season.

Although historically some fishing occurred off the northern coasts of the South Shetland Islands, recent fishing operations that could impact chinstrap penguins do not overlap with the breeding season (November to March). Adult chinstrap penguins move to the pack ice during the non-breeding season (April – October), staying within 500km of the colony[6], but the distribution of juvenile chinstrap penguins after the breeding season is still unknown. There is still no clear link between local fishing pressure and population dynamics of penguins. This may be a result of the lack of specific information on the relevant environmental drivers, which means that these factors cannot be accounted for in qualitative analyses of penguin population dynamics and fishing activity.

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[4] Watters GM, Hinke JT and CS Reiss. 2020. Long-term observations from Antarctica demonstrate that mismatched scales of fisheries management and predator-prey interaction lead to erroneous conclusions about precaution. Scientific Reports, 10(1), 1–9. https://doi.org/10.1038/s41598-020-59223-9

[5] Santora JA, LaRue MA and DG Ainley. 2020. Geographic structuring of Antarctic penguin populations. Global Ecology and Biogeography, geb.13144. https://doi.org/10.1111/geb.13144

[6] Hinke, J.T., Santos, M.M., Korczak-Abshire, M., Milinevsky, G. and Watters, G.M., 2019. Individual variation in migratory movements of chinstrap penguins leads to widespread occupancy of ice-free winter habitats over the continental shelf and deep ocean basins of the Southern Ocean. PloS one, 14(12), p.e0226207.

V.3. Whale distribution and consumption

Whales are important krill predators but are currently not considered as a source of variable krill mortality in the management of the krill fishery or the design of the VRZs.

Humpback whales are increasing in numbers, and there is considerable information on this species in the Antarctic Peninsula area. This population is growing at a high rate and showing signs of recovery[7]. Humpback whales use the Antarctic Peninsula area during January-June as a feeding ground[8]to recover from and prepare for Austral winter migration to the Equator. During this period, they distribute mainly in ice-free waters with high krill densities and secondarily by following oceanographic and physical features that aggregate krill. Thus, Humpback whales are widely distributed early in the feeding season (January-March), exploiting the continental shelf region and nearshore bays and in the Gerlache and Bransfield Straits. In contrast, during April-June, they concentrate closer inshore, particularly at coastal bays within the Gerlache and Bransfield Straits. These whales migrate from the Antarctic to tropical breeding grounds beginning in April, depending on the age and reproductive state of the individual.

Minke whales also forage on dense krill patches but favour areas close to shore and where sea ice (or glacial) ice is present[9,10,11]. There are no current comprehensive population assessments for minke whales in this region. Fin and blue whales, once abundant in the Antarctic Peninsula area, have not yet shown signs of recovery.

As whales require dense krill patches for efficient foraging, it is likely that the krill fishery and baleen whales are targeting similar krill patches. This may result in competition if the two influence each other's behaviour or if there is a shortage of krill. This could happen if either of the two is capable of substantially decreasing the resource in the Gerlache and Bransfield Straits and associated bays. Following the temporal development in local removals and comparing the two sources may provide more information on whether one is likely to impact the other on a local scale and, if combined with information from spatially attached predators like penguins, can provide an indication of whether the two together impact other predators.

The available information on whale distribution is not detailed enough to relate to the VRZs and associated management regulations. The current placement and timing of VRZs covers some but not all of the critical foraging areas for baleen whales around the Antarctic Peninsula. The northern portion of the Gerlache Strait and Charlotte Bay, as well as Dallman Bay, which are not included in the VRZs, are known to be highly used foraging areas for baleen whales throughout the feeding and krill fishery

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[9] Friedlaender AS, Goldbogen JA, Nowacek DP, Read AJ, Johnston DW and N Gales. 2014. Feeding rates and under-ice foraging strategies of the smallest lunge filter feeder, the Antarctic minke whale (*Balaenoptera bonaerensis*). Journal of Experimental Biology, 217:2851-2854.

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season. Similarly, the areas of the Bransfield Strait that are not covered by the VRZs also comprise highly used foraging areas for baleen whales and the krill fishing industry[12]. This said, there is still no comprehensive information on the habitat use and foraging patterns of the Bransfield Strait by baleen whales when krill fishing occurs. Not only is the Bransfield Strait used by humpback and minke whales, but fin whales are also known to use this area currently and historically.

V.4. Krill stock status

No new information is currently available on krill abundance or biomass in Subarea 48.1 in the 2019/20 fishing season. The EP understands that Chinese scientists have conducted surveys of the US-AMLR grid in many recent years and will seek to use these data to provide an update on krill stock status in the next EP report. As per the EP-2019 report, data for 1996 to 2011 suggest that krill biomass in the US-AMLR grid fluctuates from year to year, and there is no evidence that it is affected by the distribution of krill catches or of a coherent trend over that time period.

Recent publications provide new evidence on the distribution of different krill stages in the Subarea 48.1. The Subarea contains habitat for all life stages, some of which are rare or absent in other fishing areas. The emerging picture is that recruitment is synchronous along the Antarctic Peninsula[13,14] and includes elements of local recruitment, as well as occasional strong influxes from the Weddell Sea[15].

V.5. Ecosystem-Based Fishery Management

The CCAMLR principles of conservation provide a foundation for managing the krill fishery within the framework of Ecosystem-based fisheries management, EBFM. These principles identify various objectives, including "maintenance of ecological relationships" and "minimization of the risk of [irreversible] changes." EBFM could, among other aspects, accommodate such objectives as well as the stated objective of the VRZs, which is to "reduce interference with colonies of penguins during the peak of their breeding period." EBFM furnishes a holistic way of managing fisheries, considering the complex dynamics between target and non-target species and the greater social-ecological system[16]. An EBFM should be designed to be adaptive in response to changes in environmental conditions and scientific knowledge, to account for uncertainty and the mix of different societal goals and objectives[17]. For the Antarctic krill fishery, this entails that a full EBFM should:

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[12] Weinstein BG, Double MC, Gales N, Johnston DW and AS Friedlaender. 2017. Identifying overlap between humpback whale foraging grounds and the Antarctic krill fishery. Biological Conservation, 210:184-191.
[13] Perry FA, Atkinson A, Sailley SF, Tarling GA, Hill SL, Lucas CH and DJ Mayor. 2019. Habitat partitioning in Antarctic krill: Spawning hotspots and nursery areas. PloS one, 14(7), e0219325.
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[15] Reiss CS, Hinke JT and GM Watters. 2020. Demographic and maturity patterns of Antarctic krill (*Euphausia superba*) in an overwintering hotspot. Polar Biology, 43:1233-1245.
[16] Trochta JT, Pons M, Rudd MB, Krigbaum M, Tanz A and R Hilborn. 2018. Ecosystem-based fisheries management: Perception on definitions, implementations, and aspirations. PLoS ONE 13(1): e0190467. https://doi.org/10.1371/journal.pone.0190467
[17] Fogarty MJ. 2014. The art of ecosystem-based fishery management. Canadian Journal of Fisheries and Aquatic Sciences, 71(3), 479-490.

1. Adapt to changes in environmental conditions affecting krill productivity and account for uncertainty in krill biomass and productivity
2. Define the relevant societal goals and objectives, keeping in mind that human activities are also part of EBFM, and determine acceptable trade-offs between different objectives
3. Define a process for updating the management as more knowledge becomes available

In fisheries for highly productive and variable species such as krill, well-resolved data in time and space is key to ensuring the best possible management. There exists ample potential for ARK to contribute to the process of collecting and analysing data relevant to the management of the fishery, with benefits for both fishery yields and societal objectives. Several types of data could improve forecasting models used in the management of the krill fishery, including information on removals by natural predators, growth rate/energy content, size composition, distribution and biomass indices. Due to the complexity and the limitation of data access, alternative considerations to management that are context-specific might be a less complicated and useful way for operational EBFM[18]. The VRZs can be considered such a context-specific initiative and a relevant initiative source of information and data on the way towards EBFM.

ARK and its members are currently supporting several initiatives supporting EBFM in the context of management of the krill fishery. These include conducting annual acoustic surveys for estimating krill biomass at the subarea scale, determining intra-annual changes in krill density, and developing new technology for near real-time monitoring of krill density. Additional projects supported through the Antarctic Wildlife Research Fund (AWR) have focused on krill movement and connectivity, distribution of penguins, flying seabirds and whales and their overlap with krill hotspots and the fishery.

The VRZ initiative would appear stronger if the motivation and goals were well defined and scientifically founded with respect to EBFM. However, reviewing the ARK Commitment in relation to an EBFM framework is challenging as neither CCAMLR nor ARK has identified specific EBFM objectives. For example, the ARK Commitment is almost exclusively focused on the impacts of krill fishing on the conservation of penguin populations. The EP unequivocally stated the need to bring in other elements to the discussion to ensure that the EBFM issues are given appropriate attention in the coming years.

[18] Trochta JT, Pons M, Rudd MB, Krigbaum M, Tanz A and R Hilborn. 2018. Ecosystem-based fisheries management: Perception on definitions, implementations, and aspirations. PLoS ONE 13(1): e0190467. https://doi.org/10.1371/journal.pone.0190467

Appendix 1. Affiliation of the members of the Expert Panel 2020

MEMBER	AFFILIATIONS & POSITIONS (last 5 years)
Olav Rune Godø 	• Advisor Norwegian Research Centre (2018 -) • Scientific Advisor AkerBiomarine (2018 -) • SC-CCAMLR Representative for Norway (2012-2017) • Senior Scientist Institute of Marine Research, Bergen, Norway – 2017
Simeon Hill 	• British Antarctic Survey
Taro Ichii 	• Senior Researcher of Fisheries Resources Institute, Japan (2018 -) • Director Oceanic Resources Division of National Research Institute of Far Seas Fisheries(2015-2017) • SC-CAMLR Representative for Japan (2014 -).
Grant Humphries 	• Director, Black Bawks Data Science (2017 -) • Post-doctoral fellow, Stony Brook University (2015 -2017) • Post-doctoral fellow, UC Davis (2014 - 2015) • Post-doctoral researcher, Farallon Institute (2014 - 2015) • SC-CCAMLR / CCAMLR advisor to Oceanites (2016 -)
Rodolfo Werner 	• Senior Advisor of The Pew Charitable Trusts and Antarctic and Southern Ocean Coalition (2003 -) • SC-CCAMLR Representative for ASOC (2003 -) • Science Advisor of Antarctic Wildlife Research Fund (AWR) (2015 -)
Anna Rindorf 	• Head for Ecosystem based Marine Management, National Institute of Aquatic Resources, Technical University of Denmark (2013 -)
Ari S. Friedlaender 	• Associate Researcher, Institute for Marine Sciences, University of California Santa Cruz (2017 -) • Associate Professor, Marine Mammal Institute, Department of Fisheries and Wildlife, Oregon State University, Newport, OR (2013 – 2017)
Javier A. Arata 	• Executive Officer of ARK (2018 -) • General Manager of CRC IDEAL (Research Center on Dynamics of High Latitude Marine Ecosystems) from University Austral of Chile (2016 - 2018). • Science Advisor for the Chilean Institute for Antarctic Research, INACH (2014 - 2015). • SC-CAMLR Representative for Chile (2009 - 2015).

Appendix 2. Best Commercial Effort - revised

ARK recognizes that the implementation of the best commercial effort is a difficult issue to assess by the Expert Panel – as well as a difficult concept from an operational perspective. Nonetheless, in keeping the ARK Commitment and discussions during the Review Panel 2019, ARK will continue applying its Best Commercial Effort during the duration of the ARK Commitment.

Best Commercial Effort *(Revised 2019)*

Guidelines

- Every ARK vessel will make conscious efforts to remain outside of the VRZs year-round. Thus, fishing effort will be primarily planned and targeted to areas outside VRZs, also in periods outside of seasonal closures.

- Engagement of fishing within VRZs will proceed only after scouting of surrounding areas has been conducted, and fishing performances have proved to be insufficient.

- These guidelines apply outside of the seasonal closures of the VRZs, e.g., from 1 February to 31 October.

Operational Aspects

- ✓ Seasonal closures (October to end of February, depending on area) are absolute.
- ✓ During 1 March to 30 September, vessels affiliated to ARK will plan for and focus their commercial effort to areas outside the VRZs.
- ✓ Thus, fishing search efforts after March 1st should focus on areas outside the VRZs.
- ✓ Factors such as quality and composition of catches, wind, surf, sea-ice presence and spreading of fishery are factors that can be considered as the basis for the operational application Best Commercial Effort.
- ✓ All vessels should refrain from fishing in the Southern Gerlache Strait VRZ.

- ✓ The above will be assessed each season by comparing current fishing pattern against the distribution of the fleet for the 2009/10 – 2017/18 period.