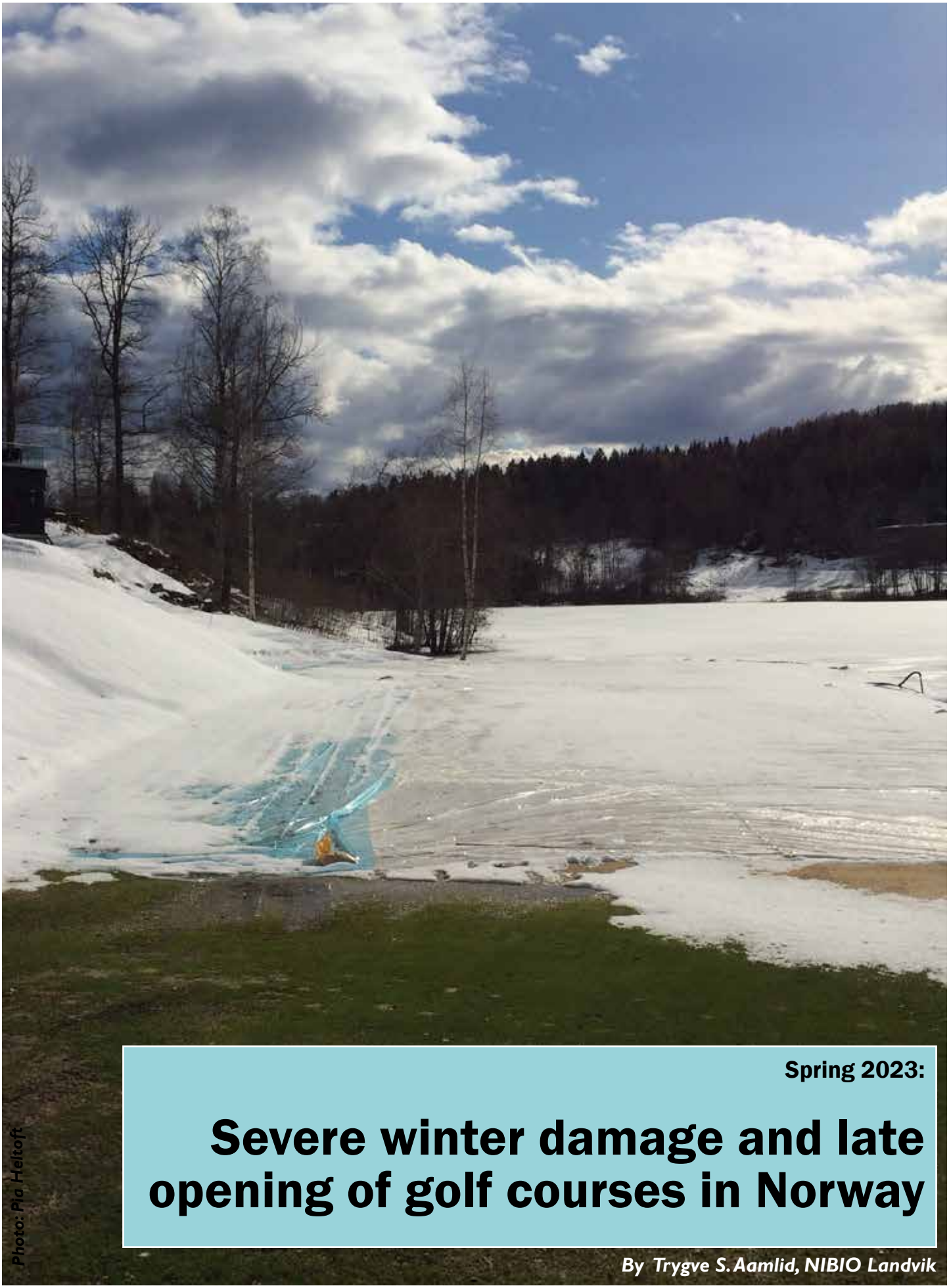

Photo: Pia Heltoft

Spring 2023:

Severe winter damage and late opening of golf courses in Norway

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Photo 1.*On April 27th the green on hole 18 at Asker GC, next to the club house, still had a layer of snow.*

After four winters with excellent survival of greens covered with plastic, Norwegian superintendents and researchers have learned from the winter 2022-23 that impermeable covers is no guarantee for perfect winter survival regardless of weather, grass species and green construction.

The winter 2022-23 was extraordinary long, and together with poor acclimation in the fall, up to 160 days with heavy snow or ice above the plastic was more than many Poa greens could endure. In retrospect, the critical question asked by many Norwegian superintendents is whether greens would have survived better without covers during this winter?

Last winter in ICE-BREAKER

For Nordic golf courses, the winter 2022-23 was not only the toughest winter since 2017-18, but it was also the last winter in 'ICE-BREAKER', a project funded by the Scandinavian Turfgrass and Environment Research Foundation (STERF) and the Research Council of Norway. When the project started in 2020, the participating golf courses in the Oslo area already had two years of experiences with impermeable winter covers, and these experiences were so positive that it was decided not to include uncovered greens in the large scale, on-course trials. Instead, we have for the past two winters investigated the need for permeable undercovers and/or sensor-based ventilation under the plastic. Based on the field trials that have been carried out, we are therefore not able to conclude whether survival during this particular winter would have been better without covers.

On 27-28 April 2023 I had the privilege to visit six golf courses around Oslo to find out what wet well and what went wrong with the plastic covers during the winter. The purpose of this article is to share my findings with a wider group of turfgrass managers.

Poor hardening conditions

In preparation for the coming winter, the stakeholders in ICE-BREAKER were gathered at Bærum GC on 10 Nov. 2022. At this meeting everyone agreed that the late fall had been unusually gray with poor hardening conditions. This is confirmed by Figure 1 which shows that the irradiance at NIBIO's weather station Lier southwest of Oslo during the hardening period from 15 Oct. to 15 Nov. was 24 % less in 2022 compared with the four-year average for 2018-2021. At the same time, the average soil temperature during this 'winter preparation period' was as much as 1.4°C higher than the year before (Figure 1).

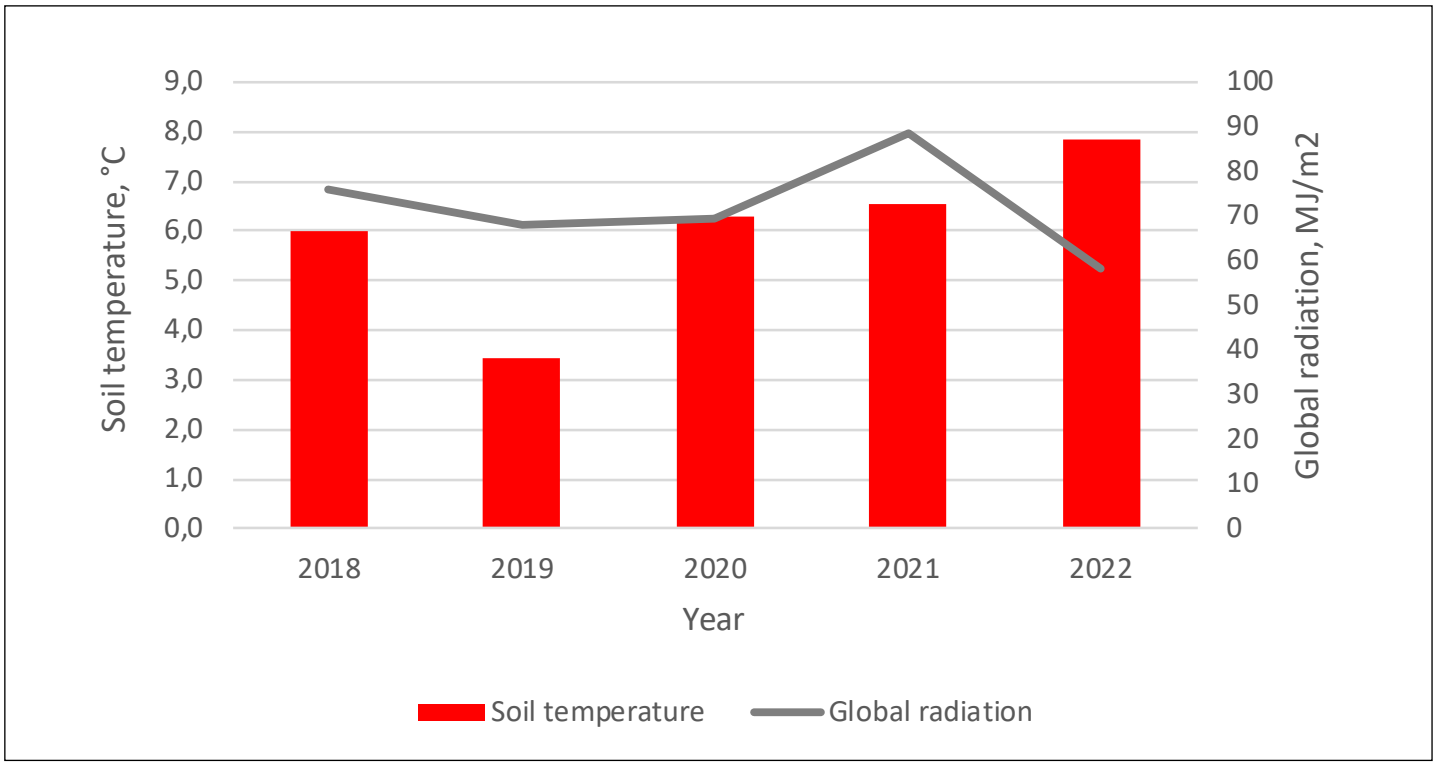

Figure 1. *Average soil temperature at 10 cm depth and total solar radiation during the period 15 Nov. – 15 Dec. in 2018, 2019, 2020, 2021 and 2022 at NIBIO's weather station Lier southwest of Oslo (59.8 °N, 10.3 °E)*

Most golf courses in the Oslo area close (or ought to close!) for the season around 15 Oct. From then until coverage with plastic in November we want the weather to be bright and sunny. High irradiance during this period will trigger the grass to maintain a high level of photosynthesis, but with restricted growth due to low temperatures. Such conditions will stimulate the accumulation of carbohydrate reserves in turfgrass crowns, stolons and rhizomes, which is a crucial part of the acclimation process before winter. Towards the end of this period, we also want the moderate freezing night temperatures which makes plant membranes more flexible and permeable for water. However, unlike the four previous years, there was not a single night with freezing temperatures during the two first weeks of November 2022!

Long winter with little frost in the soil but plenty of snow and ice

All greens at the participating golf courses were covered with plastic between 14 Nov. and 19 Nov. The first snow came on 21-22 Nov., but only around 5 cm and not enough to prevent freezing temperatures in the top 10 cm of sand-based greens during the winter's two coldest weeks from 5 Dec. to 19 Dec. During this cold spell, the sensors measured temperatures down to -5 °C under the plastic sheets (Figure 2a).

However, the frost did not penetrate deeply into the rootzones and after more snow had covered the greens, the soil thawed bottom-up on most greens from January already. On the particular green at Asker GC shown in Figure 1, the maximal snow depth was about 120 cm and the superintendents were not able to remove the plastic until 18 April, i.e. after a cover period of 152 days.

One of the most important characteristics of this winter was that a mild and unstable February with a number of thaw/freeze events was followed by an unusually cold March that delayed snow and ice melt until late April. At NIBIO's weather station, the mean monthly temperatures in February and March were -0,3- og -1,5°C, respectively. A lower mean temperature in March than in February resembles the situation in 2017-18 which was the last winter with severe damage on many Norwegian golf courses.

A good thing about the snow cover at Asker GC was that it was deep enough to absorb most of the melting water during the thaw events in January and

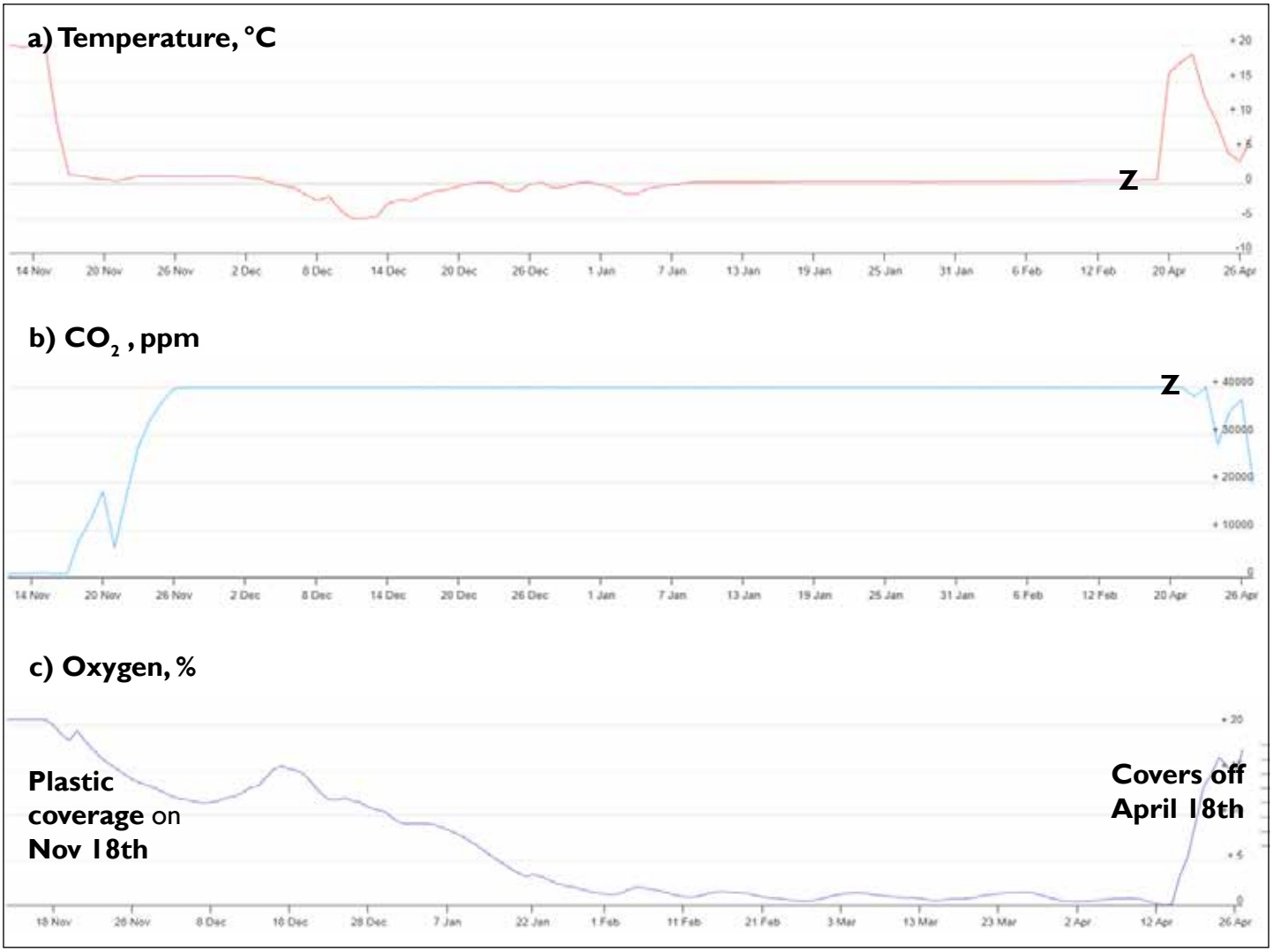

Figure 2. *Temperature, CO_2-concentration and O_2-concentration in the thatch / mat layer on green no 10 at Asker GC. This particular green had no spring tarp allowing 'oxygen pockets' under the plastic and there was severe winter damage due to oxygen deficiency and /or accumulation of CO_2 and possibly other toxic substances. Please note that the CO_2-sensor had a maximum detection limit of 40000 ppm (4 %); in reality, the concentration was probably much higher.*

February. Thus, there was little formation of ice over the plastic surface under the snow. This situation was different on other golf courses where the snow depth was only 50-70 cm and where a 10-15 cm ice layer built up between the plastic and the snow during winter (Photo 2).

CO_2 accumulation and anoxia

The weight of the thick ice and snow layers caused the impermeable covers to be pressed against the green surface with no or very little opportunity for air pockets to form. On greens where drainage pipes had been installed under the plastic for ventilation, the

Photo 2. *A 10 cm compact ice layer on top of the plastic after clearing the snow on 13 April at Haga GC. Photo: Gavin Jagger.*

Photo 3. *Depression caused by ventilation pipe on the winter-killed green 17 at Bærum GK, Oslo. This green had a 10-15 cm think ice layer + a 40-60 cm snow layer above the plastic for almost four months. Ventilation was successful in November and December, but impossible after that due to the heavy burden of ice and snow above the plastic. Photo: Trygve S. Aamlid.*

Photo 4: *From Holtsmark GC on 27 April 2023: Green 4 (top left) had almost 100% survival after ventilation through drainage pipes under the plastic. On the practice green to the right, the grass survived in a 3-4 m wide belt on both sides of a drainage pipe, but was mostly dead on other parts of the green. The most severe winter damage was seen on green 14 (bottom left) which neither had ventilation pipes nor a tarp under the plastic. Photos: Trygve S. Aamlid.*

pipes were often pressed into the green surface by the ice and/or snow above it (Photo 3).

When combined with a 3-4 week longer cover period than during the previous winters, this heavy layer resulted in oxygen deficiency and the accumulation of CO_2 og other toxic and bad-smelling substances under the plastic. On some greens, the O_2 concentration was less than 1% for 8-12 weeks (Figure 2c). Such a low concentration over such a long period was never encountered during the past year in 'ICE-BREAKER'.

Positive impact of ventilation on some greens

Unlike the situation in Photo 3, we did see a positive effect of ventilation pipes laid out under then plastic in lower areas on several greens.

At Holtsmark GC, this was very evident on a practice green where annual bluegrass survived in a 3-4 m wide belt on both sides of the ventilation pipe (Photo 4c) but was otherwise dead. Most damage from anoxia at Holtsmark was seen on green 14 which neither had ventilation pipes nor a layer of permeable tarp between the plastic and the grass.

Excellent survival of all covered greens at Oslo GC

Oslo GC is a high budget golf course situated not far from the Holmenkollen ski jump. The course has relatively new USGA-spec. greens good with almost 100% creeping bentgrass and very little annual bluegrass. Oslo also has a Subair system that allows superintendents to ventilate and drain the rootzone for excess water before winter. Given these favorable conditions, it is perhaps not surprising that the greens had a 100 % winter survival and appeared almost impeccable in spring despite 152 days of plastic coverage (Photo 5).

Miklagard GC: Good survival after snow removal during winter

Miklagard GC about 50 km northeast of Oslo had chosen a different strategy than the other courses. Instead of using plastic sheets, the superintendents systematically followed the weather forecasts and cleared the snow from all greens and surrounds when mild spell that could potentially result in melting water were predicted. According to the course manager two superintendents were 'on call' for snow removal throughout the winter.

While this strategy was highly successful during this winter, a major contributor the success may also have been that Miklagard has no greens with more than 15 % annual bluegrass. At the same GC there was, however, a lot of winter damage on tees and fairways where the snow had not been removed during the winter.

Miklagard's positive experience with snow removal is consistent with an experiment at NIBIO Apelsvoll, about 100 km further north, during the winter 2021-22. Due to the positive results with plastic covers, we at NIBIO have perhaps not been so good at communicating this alternative to Norwegian golf courses, but Table 1 shows that repeated snow removal was equally successful as the use of plastic covers on pure creeping bentgrass and red fescue greens. On the other hand, snow removal throughout the winter was significantly behind the use of plastic covers on pure annual bluegrass greens, most likely because annual bluegrass became more vulnerable to freezing damage in the absence of an insulating snow cover. With the last winter's experiences in mind, it is perhaps also pertinent to remind superintendents that annual bluegrass green in this experiment suffered 61% winter damage even under plastic. This emphasizes that species composition is perhaps even more important than management when it comes to winter survival of putting greens.

Photo 5. *Mowing of a practice green at Oslo GC on 27 April. Thank to good drainage, a Subair system and 100% creeping bentgrass, and despite no ventilation pipes, this green survived 152 days under plastic cover. Photo: Morten Günther.*

Table 1. *Per cent winter damage of creepinig bentgrass ('Riptide' + 'Independence'), red fescue (blend of Chewings fescue and slender creeping red fescue varieties) and annual bluegrass (local green's type) as influenced by different conditions / treatments during the winter 2021-22 at NIBIO Apelsvoll Research Center (inland site, 140 km north of Oslo).*

	Control ('natural' winter, no actions taken)[1]	10 cm compact ice directly on green, no plastic [2]	Impermeable plastic under 10 cm compact ice [2]	Snow removal throughout winter	Mean
% winter kill assessed in mid May, three weeks after start of growth					
Creeping bentgrass	5	97	4	0	27
Red fescue	4	85	4	0	23
Annual bluegrass	97	100	61	89	87
Mean	35	94	23	30	46

1)The control treatment had a snow cover varying in depth from 0 to 25 cm. Under the snow there was occasional formation of up to 5 cm of porous ice.
2) Cover period was 142 days.

Conclusion

The last winter in the ICE-BREAKER project has given us a more balanced picture of the benefits, but also the risks associated with the use of impermeable plastic covers on golf course putting greens during the winter. With cover periods up to 150 days, annual bluegrass greens are likely to suffer damage from hypoxia / anoxia, particularly if hardening conditions in the fall have been inadequate and there is no or little frost in the soil. Apart from the duration of the cover period, snow and/or ice depth above the covers seem to have an impact on the risk for oxygen deprivation and the accumulation of CO_2 and toxic substances under the plastic.

One of the most important lessons learned is that an impermeable plastic layer can not compensate for basic factors such as correctly constructed and well-drained greens with no inlet of water, either on the surface or through the green profile.

Despite the additional, but valuable experiences during the last winter, the project as a whole suggests that the careful installation of impermeable plastic covers pays off in four out of five years.

The use of a spring tarp to create space and to absorb humidity under the plastic is recommended, and on annual bluegrass greens it is also a good insurance to install a ventilation system under the plastic.