Connecting Îles-de-la-Madeleine
to the transmission system

Impact of electric and magnetic fields generated by subsea cables on lobster and snow crab

Project summary

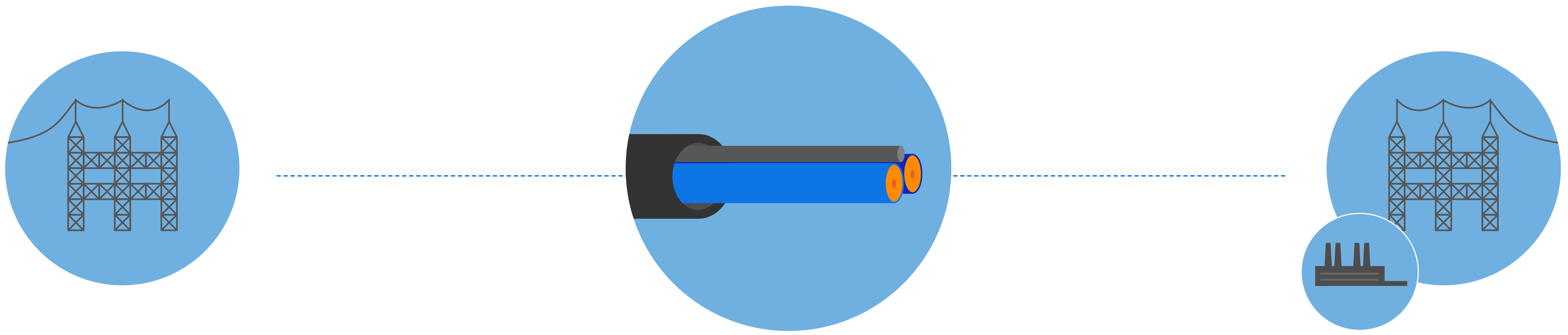
The project consists in connecting Percé (Gaspésie) and Cap-aux-Meules (Îles-de-la-Madeleine) substations with an underwater link between both shores and an underground link between the shores and substations. Once the project is complete, the Îles-de-la-Madeleine thermal generating station will be used during winter peaks and when the link is undergoing repairs or maintenance.

The underwater portion of the link will be approximately 220 km long and will consist of two 160-kilovolt (kV) direct-current electric cables and one fiber optic cable. The current's annual average intensity will be 234 amperes (A) with peaks of 461 A for a few hours at a time.

Percé substation

Line composed of two 160-kV direct-current electric cables and one fiber optic cable

Cap-aux-Meules substation and thermal generating station



Reduction in greenhouse gas emissions

Currently, the thermal generating station:

Consumes
36 million
litres of heavy fuel oil every year.

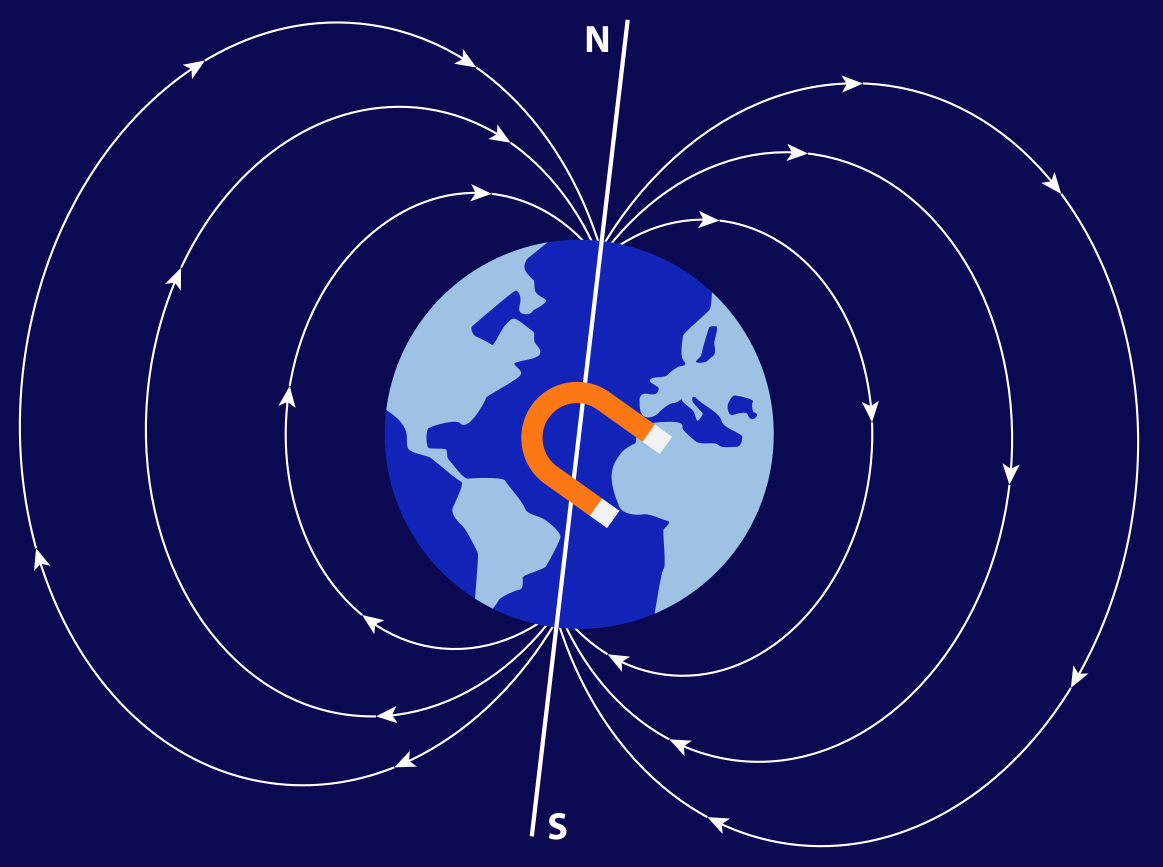
Emits
35%
of Hydro-Québec's direct greenhouse gas (GHG) emissions.

The connection to the main grid will cut GHGs **by 94%.**

Earth's magnetic field

The Earth's magnetic field is everywhere in the environment. It ranges from 25 microteslas (μT)* to 60 μT depending on the location, with slight variations throughout the year.

The Earth's magnetic field is 53.31 μT at Percé and 52.47 μT at Cap-aux-Meules. Between these locations, it averages 52.83 μT and varies by about 0.1 μT per year.



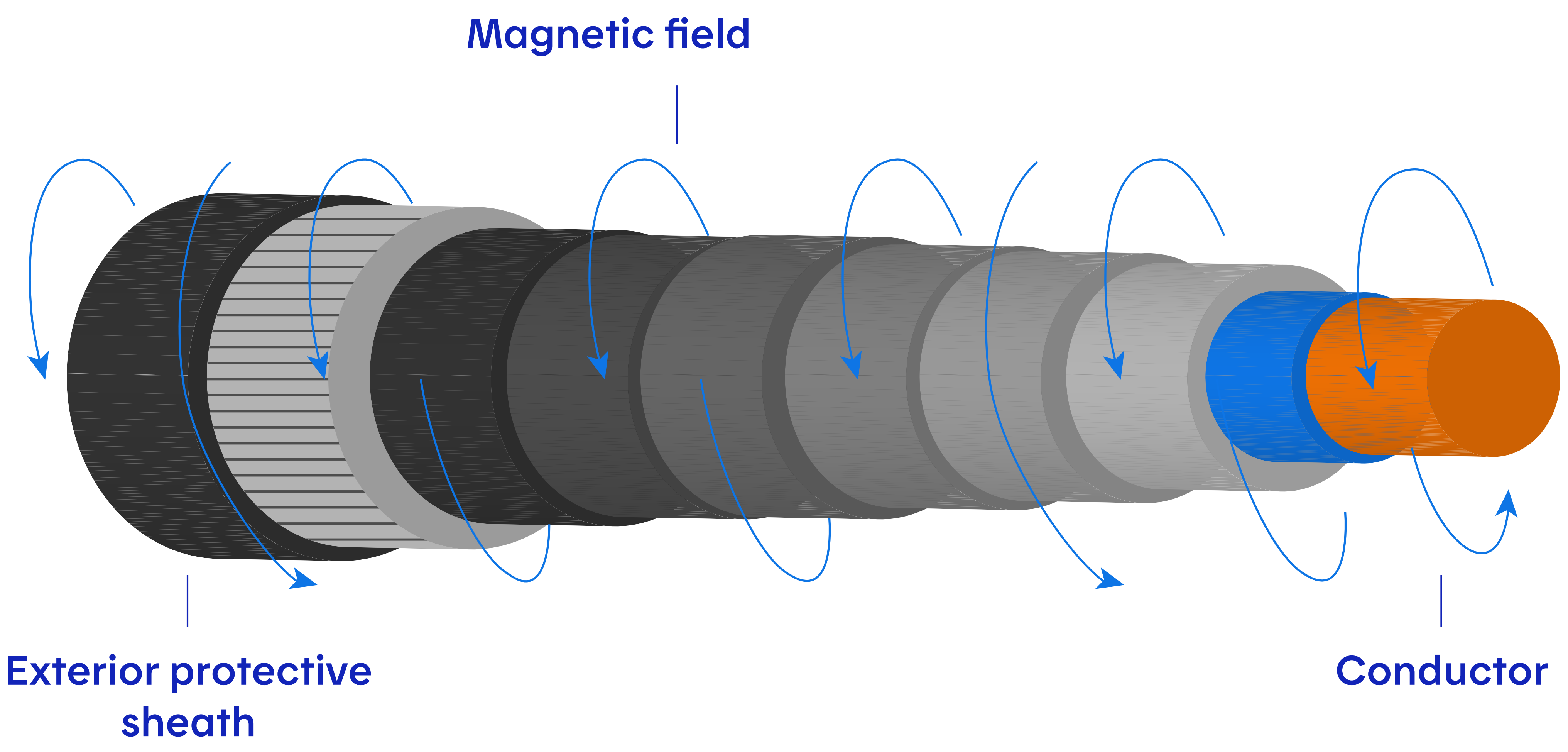
* Magnetic field strength is measured in teslas (T). A microtesla (μT) is one millionth of a tesla.

Magnetic field generated by subsea cables

The direct current flowing through the cables will generate a magnetic field that will alter the Earth's magnetic field near the cables.

Seasonal migrations observed in certain species of crabs and lobsters suggest that these crustaceans are able to detect variations in the magnetic field and that they use them to find their way.

However, no study has shown that live cables have a significant ecological impact on marine species populations.



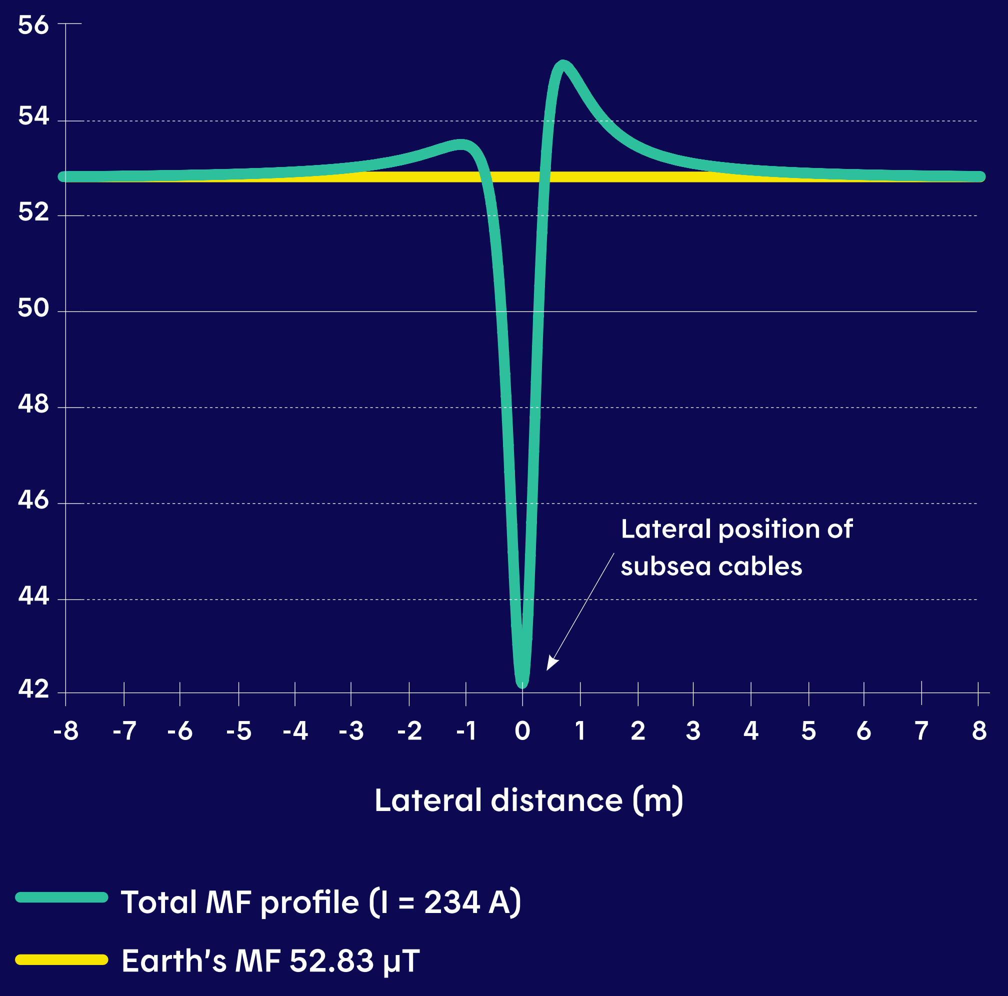
Effect of cables on the natural magnetic field

The magnetic field created by the direct current flowing in the cables will alter the natural magnetic field in their vicinity. The higher the intensity of the current flowing in the cables, the greater the generated magnetic field will be.

However, it will be very localized. The average intensity of the current is expected to be 234 A, and, at 6 m from the cables and beyond, the effect of the cables will be similar to natural variations in the Earth's magnetic field.

Within 6 m from the cables, the effect of the generated magnetic field will generally be minimal because the cables will be buried or covered, keeping marine organisms away from the area where the disturbance will be greatest. In addition, the altered magnetic field will, for the most part, be present above the cables only. With an intensity of 234 A and 0.5 m of protective covering, the magnetic field emitted above the cables will not exceed 12 μT. This will cause a variation of 42.58 μT to 55.13 μT in the total magnetic field around the cables.

Magnetic field at 0.5 m above the cables including the Earth's magnetic field (μT)



Effect of the induced electric field

The electric field produced by the cables will be confined in the insulating protective sheath they are manufactured with. A weak electric current may however be induced by the circulation of a conductive element in the magnetic field generated by the cables, such as an ocean current or a fish.

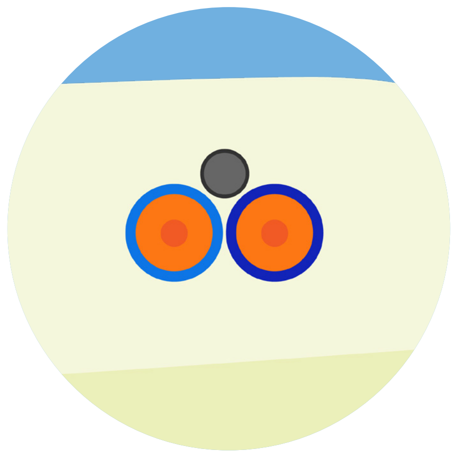
It has yet to be demonstrated that crabs and lobsters have the ability to detect electric fields. The intensity of the electric field induced by the cables will be weak and will diminish very quickly when moving away from the cables. As such, induced electric fields will not have noticeable effects on crab and lobster populations.

Line buried in a borehole or covered along the route

In both coastal areas and up to where the seabed is approximately 10 m in depth, the cables will pass through a borehole up to 60 m in depth.

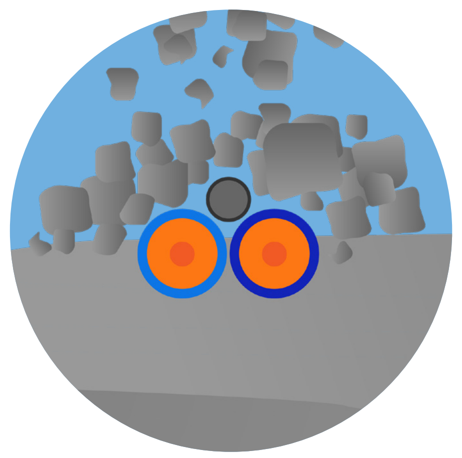
In the open sea where the seabed is greater than 10 m in depth, the cables will either be buried under approximately 0.5 m of sediment, covered with riprap approximately 0.5 m thick or, exceptionally, covered with concrete mattresses.

Cables buried under 0.5 m of sediment

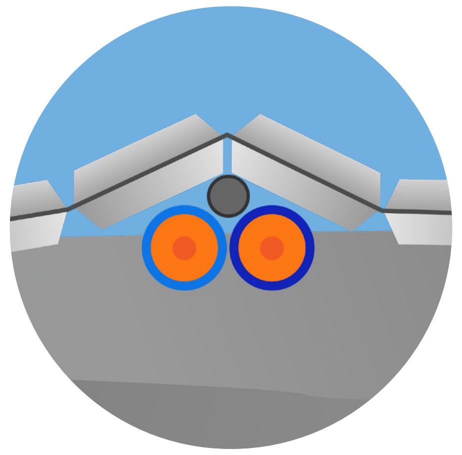


Buried

Cables lain on the seabed covered with a protective layer



Riprap



Concrete

Impact of the line on lobsters

In the coastal areas where boreholes will be drilled between the shore and where the seabed is approximately 10 m in depth, the cables will have no effect whatsoever as they will pass through the borehole, which will reach up to 60 m in depth.

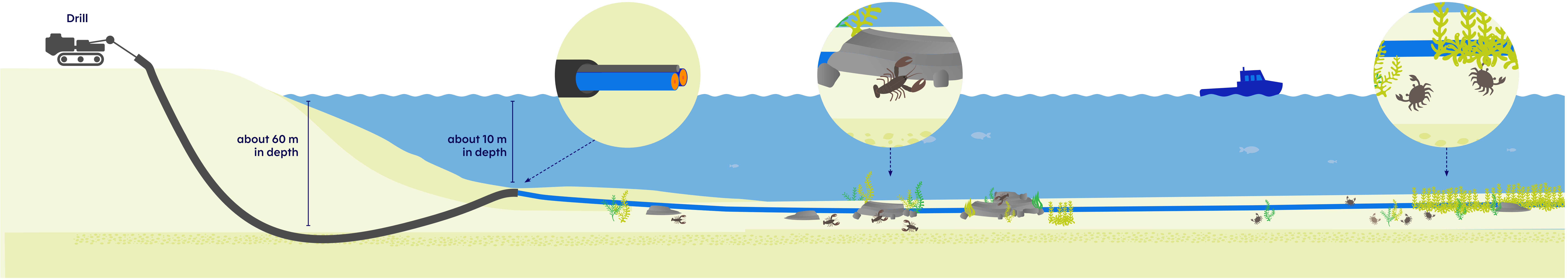
The impact on lobsters venturing into areas where the seabed is more than 10 m in depth will be minimal. Because the cables will be buried at a depth of 0.5 m or covered with 0.5 m of material, the disturbance in the natural magnetic field will be too localized (6 m on either side of the cables) and too weak (maximum of 12 μT for a current of 234 A) to disturb them. Field and laboratory studies have shown that when significant effects were observed on lobsters, the altered magnetic field's intensity was much greater than that which the future line will induce (see bibliography).

Thus, the cables will not have a barrier effect on lobsters. Although they will feel the alteration in the natural magnetic field, they will still be able to freely move about on either side of the cables.

Impact of the line on snow crabs

Because the cables will be buried at a depth of about 0.5 m or covered with 0.5 m of material, the disturbance in the natural magnetic field will be too localized (6 m on either side of the cables) and too weak (maximum of 12 μT for a current of 234 A) to disturb crabs.

To date, laboratory studies that have observed significant effects on crabs have been conducted with much more elevated magnetic fields than that which the cables will generate on the seabed (see bibliography). There is no reason to fear that snow crabs will experience a barrier effect, nor that snow crab populations will be affected.



A sample of studies on the impact of magnetic fields on lobster and crab

Reference	Species studied	Intensity of the applied magnetic field	Observations
Bochert and Zettler, 2004	Harris mud crab (*Rhithropanopeus harrisii*)	3,700 µT Laboratory study	No effect on survival rate.
Woodruff et. al., 2013	Dungeness crab (*Metacarcinus magister*) American lobster (*Homarus americanus*)	~1,100 µT Laboratory study	No compelling difference in behavior showing attraction or repulsion to the magnetic field.
Love et al. 2015	Two species of crab (*Metacarcinus anthonyi*), (*Cancer productus*)	46 to 80 µT In the biophysical environment with alternating-current subsea cables	No difference in behavior observed (no repulsion or attraction to the live cable).
Love et al. 2017	Two species of crabs (*Metacarcinus magister*), (*Cancer productus*)	14 to 117 µT In the biophysical environment with alternating-current subsea cables	Live cables did not influence the capture rate of these two commercially important species.
Hutchison et al., 2018	American lobster (*Homarus americanus*)	48 to 65 µT In the biophysical environment with direct-current subsea cables	Subtle change in behavior near cables (e.g., more large turns akin to exploratory activity). No barrier to movement was induced by the cables.
Taormina et al., 2020	Juvenile European lobster (*Homarus gammarus*)	200 to 225 µT Laboratory study	No effect of magnetic field on ability to explore territory or seek shelter. No attraction or repulsion observed.
Scott et al., 2018, 2021	Edible crab Cancer (*Cancer pagurus*)	250, 500, 1,000, 2,800 µT Laboratory study	A physiological disturbance was observed from 500 µT (variation of certain parameters indicating stress). Behavior indicating attraction to the magnetic field and decrease in the time spent exploring the territory.
Harsanyi et al. 2022	European lobster (*Homarus gammarus*) Edible crab Cancer (*Cancer pagurus*)	2,800 µT Laboratory study (chronic exposure throughout embryonic development)	No effect on embryonic development time, larval release time or vertical swimming speed for either species. Significant developmental differences of lobster and crab eggs and larvae that may affect larval mortality, recruitment and dispersal.

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