12.10 PROJECT'S RELATION TO PLANS AND PROGRAMMES PERTAINING TO THE USE OF NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION

Table 13-1 describes the project's relation to the most important plans and programmes pertaining to the use of natural resources and environmental protection. These include both international commitments and national target programmes which, while not being directly binding upon the undertaking, may concern the undertaking through various permits and licences, for example.

Table 13-1. Project's relation to plans and programmes pertaining to the use of natural resources and environmental protection.

Name of programme/plan	Content	Relation to project
Paris Agreement	A new legally binding international treaty on climate change was adopted at COP 21 in Paris, on 12 December 2015. The Paris Agreement entered into force on 4 November 2016 and became binding on Finland on 14 November 2016. The Paris Agreement aims to limit global warming to well below 2 degrees Celsius, compared to pre-industrial times, and to pursue measures which would limit the warming to 1.5 degrees Celsius. The objective is to achieve the peak of global greenhouse gas emissions as soon as possible and to reduce emissions quickly after that in such a way that human-derived greenhouse gas emissions and sinks are in balance by the second half of this century. In addition to the objectives of emission reduction, the agreement sets the long-term target of adapting to climate change and the target of adjusting financing flows toward low-carbon and climate-resilient development. The global stocktakes held at five-year intervals review the parties' joint progress in relation to the agreement's goals. The first global stocktaking will take place in 2023.	Electricity production based on nuclear power does not generate greenhouse gas emissions. Therefore, the extended operation of Loviisa nuclear power plant would support emission reduction targets in line with the Paris Agreement.
The EU's climate and energy policy 2020 and 2030	The European Council agreed on the EU's energy and climate objectives for the 2021–2030 period in 2014. The new objectives are a continuation of the 2020 framework agreed on in 2007. The goal by 2030 is to reduce greenhouse gas emissions on the EU level by 40% compared to the level in 1990. The goal has been divided into a 43% emission reduction in the emissions trading sector (big industrial and energy production plants) and a 30% emission reduction in industries outside the emissions trading, compared to 2005.	Electricity production based on nuclear power does not generate greenhouse gas emissions. Therefore, the extended operation of Loviisa nuclear power plant would support the goals of the EU's climate and energy policy.
Finland's national energy and climate strategy	Finland's long-term goal is a carbon-neutral society. The Energy and Climate Roadmap 2050 report published in 2014 by the Parliamentary Committee on Energy and Climate Issues functions as a strategic guideline towards this goal. The roadmap assessed the means by which to build a low-carbon society and for reducing Finland's greenhouse gas emissions by 80–95% from the 1990 level by 2050. The energy and climate policy has three main dimensions the balance of which must be managed continuously whilst shifting towards a carbon neutral society. The energy system must be i) cost-effective and enable the growth of the national economy and the competitiveness of Finnish companies on the global market, ii) sustainable from the perspective of greenhouse gas emissions and the environment, and iii) sufficiently secure in terms of supply.	Electricity production based on nuclear power does not generate greenhouse gas emissions. Therefore, the extended operation of Loviisa nuclear power plant would support the goals of Finland's national energy and climate strategy. In addition, nuclear energy supports the continuity of supply in Finland's electricity production.
New climate and energy strategy	The government is preparing the climate and energy strategy in line with Prime Minister Sanna Marin's Government Programme under the leadership of the Ministry of Economic Affairs and Employment. Sanna Marin's Government Programme aims to achieve carbon neutrality in Finland by 2035 and a zero carbon level soon after. The strategy is being prepared in coordination with the intermediate-term climate plan, which is coordinated by the Ministry of the Environment and defines the new policy measures of the "effort sharing" sector outside the EU's emissions trading scheme. The strategy covers all sources of greenhouse gas emissions (the emissions trading sector, the effort sharing sector, the land use sector) and sinks (the land use sector). It also includes reviews in accordance with the five dimensions of the EU's Energy Union (low-carbon, including renewable energy, energy efficiency, the energy markets, energy security and RDI measures), adapting to climate change, energy and greenhouse gas balances, and comprehensive impact assessments on the selected set of policy measures (environmental impacts, gender equality, national economy, fiscal economy as well as social and regional impacts). In addition, the strategy may highlight other topical energy and climate policy themes, such as energy's security of supply. The main focus in both the policy measures outlined in the strategy and the scenarios based on them is on achieving the climate and energy goals for 2030 set by the EU and the government programme's carbon neutrality 2035 goal.	The use of nuclear power in electricity production supports Finland's goal, pursuant to the Programme of Prime Minister Sanna Marin's Government, of being carbon neutral by 2035, which would require heat and power production in Finland to be nearly emission-free by the end of the 2030s, taking into account the perspectives of maintenance and delivery reliability. According to the programme, the extended permits and licences of existing nuclear power plants will be regarded positively, provided that STUK is in favour of it.
National Air Pollution Control Programme 2030	The National Air Pollution Control Programme 2030, approved by the government in March 2019, is a key instrument in the implementation of EU obligations and the objectives of national air pollution control. The programme includes the measures needed to implement the emission reduction obligations set by the EU's NEC Directive (2016/2284) and other actions needed to improve air quality.	The production of nuclear energy does not generate emissions restricted by the NEC Directive. The extended operation of the nuclear power plant supports the achievement of Finland's goals, given that energy production based on incineration processes would be replaced by nuclear power.
Water Framework Directive **Water resources management plans and programmes of measures**	The EU's Water Framework Directive (2000/60/EC) was adopted in 2000. The Directive aimed to define the framework for the protection of inland surface waters, estuaries, coastal waters and groundwaters. According to the Water Framework Directive, member states must identify the river basins within their territories and assign them to individual river basin districts. A water resources management plan must be prepared for each river basin district. Each plan includes a programme of measures which must fulfil the Directive's goals. On the national level, the EU's Water Framework Directive is implemented with the Act on the Organisation of River Basin Management and the Marine Strategy (1299/2004), the Government Decree on Water Resources Management Regions (1303/2004), the Government Decree on Water Resources Management (1040/2006), the Government Decree on the Organisation of the Development and Implementation of the Marine Strategy (980/20119 and the Government Decree on Substances Dangerous and Harmful to the Aquatic Environment (1022/2006). The water resources management plans and the programmes of measures complementing them provide information on the status of the waters and the factors impacting them, as well as on the measures needed to achieve and maintain a good status of waters. The valid plans and programmes of measures cover the years 2016–2021. The hearings on the water resources management plans and programmes of measures for 2022–2027concluded in May 2021 and the plans will be adopted by the end of 2021.	The water resources management plan for the river Kymijoki-Gulf of Finland river basin district covers the Gulf of Finland's coastal areas and the programme of measures of Uusimaa's water resources management covers the coastal area of Loviisa. The power plant's most significant impact is the thermal load carried to the waterways, which has had an adverse effect mainly on the status of the Klobbfjärden body of water. The proposal on the programme of measures for Uusimaa's water resources management mentions the planning and implementation of the eutrophied bay's rehabilitation as Klobbfjärden's measure. Measures for the operation, maintenance and increased efficiency of plants are also presented to the industrial sector for the third water resources planning period.

Name of programme/plan	Content	Relation to project
Marine Strategy Framework Directive **Finland's Marine Strategy**	The Marine Strategy Framework Directive (2008/56/EY) is a directive on the framework for a marine environmental policy creating a framework and objectives for the preservation of the marine environment and its protection from the noxious activity of humans and for the prevention of noxious activity by humans. Finland's Marine Strategy implements the EU's marine policy and the relevant directive on the national level. The planning of the Marine Strategy is divided into three parts and progresses in six-year cycles. The initial stage of Finland's Marine Strategy involved an assessment of the sea's present state and the setting of the objectives needed for the attainment of a good status as well as indicators for monitoring the status. The Marine Strategy covers Finland's territorial waters and exclusive economic zone. The Marine Strategy's programme of measures includes suggested measures that would improve the status of the sea. The valid programme of measures covers the years 2016–2021. Hearings on the Marine Strategy's programme of measures for 2022–2027 and its background materials concluded in May 2021. The government is set to adopt the new programme of measures in December 2021.	This EIA Report includes an assessment of the impacts on the status of the sea area. According to the assessment, the thermal effect of the cooling water is local and has contributed to a local increase in eutrophication over the long term. In the proposal concerning the Marine Strategy's programme of measures, the thermal effect of the cooling water is deemed local enough not to have impact on the status of the sea.
Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM) **Baltic Sea Action Plan (BSAP; HELCOM)**	The Convention on the Protection of the Marine Environment of the Baltic Sea Area (1974, 1992), also referred to as the Helsinki Convention, obligates the participating countries to reduce input from all emission sources, protect the marine nature and preserve biodiversity. The convention's key principles are the use of the best available technology from the perspective of environmental protection, applying the practices best in terms of the environment and compliance with the principle of prudence and the 'polluter pays' principle. The Helsinki Commission (HELCOM) is an intergovernmental organisation established by the signatories (contracting parties) to the Helsinki Convention. The commission monitors and promotes the application of the Helsinki Convention and gives recommendations to the governments of the contracting parties. HELCOM's Secretariat approved the Baltic Sea Action Plan in 2007. The action plan's objective was the good ecological status of the Baltic Sea by 2021. The action plan covers the worst environmental problems of the Baltic Sea and actions related to eutrophication, harmful and dangerous substances, biodiversity and nature protection. HELCOM and its signatories have decided to update the action plan, given that it seems unlikely that the objective of a good status will be attained by the end of 2021.	According to the environmental impact assessment, the thermal effect of the cooling water is local and has, in the long run, contributed to a local increase of eutrophication, among other things. The thermal effect does not have an impact on the ecological status of the Baltic Sea in a wider sense, as was concluded in the Marine Strategy's programme of measures.
Natura 2000 network	The European Union aims to stop the loss of biodiversity in its area. The Natura 2000 network is one of the most important means by which to attain this goal. The network safeguards the environments of the natural habitats and species defined in the Habitats Directive. These areas pursuant to the Habitats Directive are called Sites of Community Importance (SCI). The Habitats Directive applies to wild fauna, flora and natural habitats. It aims to i) attain and maintain a favourable level of conservation in terms of some species and natural habitats, ii) preserve species in their natural environments so that their natural range does not shrink, and iii) preserve a sufficient number of a species' natural habitats to ensure its survival in the future, too. The netwrok also includes Special Protection Areas (SPA) pursuant to the Birds Directive. The Birds Directive applies to Europe's wild birds. The Directive's general objective is to maintain certain bird populations on a level that meets ecological, scientific and educational requirements.	The Natura 2000 network site closest to the power plant area is the Källaudden–Virstholmen area, located approximately 1.3 km to the southwest. According to the impact assessment, the power plant's extended operation or decommissioning would not have impacts that would impair the Natura area in question.
National policy and programme for spent fuel and radioactive waste management	The most recent national policy and programme for spent nuclear fuel and other radioactive waste was published in 2015. The policy and programme is currently being updated. The national programme is a comprehensive plan aimed at ensuring that all spent fuel and radioactive waste generated in Finland is managed safely and in a way that all waste management measures from the generation of waste to its final disposal are carried out without undue delay. The national programme ensures the implementation of the national policy for spent nuclear fuel and radioactive waste. The policy can be seen as a strategy for the management of spent nuclear fuel and radioactive waste generated in Finland. The policy consists of several principles included in the Nuclear Energy Act and the Radiation Act. The principles are therefore mandatory on the undertakings and authorities. The national programme applies to all spent nuclear fuel and radioactive waste generated in Finland. One of the objectives of the updated national programme will be to develop a safe and cost-effective final disposal solution for all spent nuclear fuel and radioactive waste generated in Finland. Among other things, the attainment of this objective requires the licence and permit conditions of the plants and final disposal facilities intended for the treatment and handling of the radioactive waste generated at existing nuclear power plants to also allow the handling and final disposal of radioactive waste generated outside of their own operations.	The management of spent nuclear fuel and radioactive waste will be implemented in accordance with the national programme in the event of both extended operation and decommissioning. The reception of radioactive waste generated elsewhere in Finland at Loviisa nuclear power plant would support the objectives of the national programme currently being updated.
National Waste Plan	The National Waste Plan to 2023 sets the objectives for waste management and for preventing the generation of waste as well as the measures needed to achieve the objectives. It was adopted by the government in December 2017. The National Waste Plan will be updated during 2021. At the same time, the plan's validity will be extended to 2027. The updated Waste Plan implements the following entry in the government programme: "Create a vision for the waste sector that supports the objectives of recycling and the circular economy and extends to the 2030s. The aim is to increase the recycling rate at least to the level of the EU's targets for recycling." The renewed Waste Framework Directive and the Single-Use Plastics Directive also require new content to be incorporated into the Waste Plan. The principle in the waste management of conventional waste is what is referred to as prioritisation: 1) minimising waste 2) the reuse of waste 3) recycling as material 4) recovery as energy 5) landfill.	The power plant generates conventional waste in a manner similar to any other industrial activity. Waste containing radioactivity can be cleared from regulatory control if the activity of the waste batch falls below the limit values set by authorities. The further treatment of waste cleared from regulatory control can be identical with that of conventional industrial waste. Attention will be paid, in the event of both extended operation and decommissioning, to the minimisation of conventional waste, the appropriate handling of the waste and on final disposal in accordance with the principles of waste management and the Waste Act.

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Glossary and abbreviations

Glossary and abbreviations	
Activation products	Radioactive substances generated as a result neutron radiation (e.g. from impurities carried to the reactor within water, the materials of the reactor's internals and the pressure vessel, or the materials of external structures in the reactor's vicinity). Activation products carried within water may migrate from the reactor to other systems and contaminate them.
Sub-criticality	A state in which the chain reaction maintained by the neutrons released in fission does not occur.
AVI	Regional State Administrative Agency
Becquerel (Bq)	The measurement unit of radioactivity, refers to the decay of one radioactive atom per second. The concentration of radioactive substances in foodstuffs is expressed in becquerels per unit of mass or volume (Bq/kg or Bq/l). Multiple units of becquerel include kilobecquerel (kBq), which is a thousand becquerels, megabecquerel (MBq), which is a million becquerels, and terabecquerel (TBq), which is a thousand billion becquerels.
dB	Decibel, or a unit of the sound pressure level, which has a logarithmic scale. An increase of 10 dB increases noise by tenfold.
Decontamination	The process of removing radioactive contaminants (contamination).
Dosimeter	A device that measures radiation doses.
Equivalent (e.)	Corresponding, equal in value.
Extensometer	A device for measuring, e.g. rock movements.
ELY centre	Centre for Economic Development, Transport and the Environment.
Espoo Convention	The UNECE Convention on Environmental Impact Assessment in a Transboundary Context. The Espoo Convention lays down the general obligations for organising a hearing for the authorities and citizens of the member states in all projects that are likely to have significant adverse transboundary environmental impacts. Https://www.finlex.fi/fi/sopimukset/sopsteksti/1997/19970067 (in Finnish)
FiR 1	A TRIGA Mark II-type research reactor owned by VTT and located in Otaniemi, Espoo.
Fission products	Radioactive substances generated when fissile atomic nuclei (such as U-235, Pu-239) split into lighter substances. Fission products remain primarily in spent nuclear fuel. However, they may migrate from the reactor to other process systems as a result of a fuel leak, and thereby contaminate the other systems.
Fissurometer	A device for measuring rock mechanics. It measures changes in the distance between anchor points and allows the movements of a rock fissure to be monitored.
Diffuse source input	Chemical input entering an environment the exact origin of which is unknown. Examples include the nutrient input caused by agriculture in a catchment area.
Project area	The project area refers to the Hästholmen area, which is the location of the current functions of the power plant and the changes planned for them in the project.
Project owner	Fortum Power and Heat Oy, or the operator responsible for the implementation of the project to be reviewed in the EIA procedure.
Moderator	A substance used for the moderation of the neutrons generated in the nuclear reaction. The purpose of the moderator is to maintain the chain reaction. In a light water reactor, regular water (light water) is used as the moderator.
HP/CORD UV decontamination method	A method which can be used for the wide-scale chemical decontamination of the primary system to lower the plant's radiation levels and the activities of components. HP = permanganic acid, CORD = Chemical Oxidation Reduction Decontamination, UV = UV light.
Maintenance waste	Waste accumulated in the maintenance and repair of the nuclear power plant. Among other things, maintenance waste consists of contaminated protection and insulation materials, defective components and used tools. For the most part, maintenance waste is low-level waste.
Maintenance waste hall	A hall in the L/ILW repository in which low- or intermediate-level waste is stored. There are three maintenance waste halls in Loviisa power plant's L/ILW repository (HJT1, HJT2 and HJT3).

IAEA	International Atomic Energy Agency
IBA and FINIBA areas	IBA areas are internationally significant bird areas, and FINIBA areas are nationally significant bird areas in Finland. The parties responsible for mapping the areas are the Finnish Environment Institute and BirdLife Finland.
INES	The International Nuclear and Radiological Event Scale (INES) is a scale used for the classification of various events related to nuclear power plants or the use of radiation. It describes the severity of an emission of radioactive material and radiation exposure.
Plant parts to be made independent	The nuclear power plant's plant parts to be made independent are the interim storage for spent nuclear fuel, the liquid waste storage and the solidification plant, the operation of which will continue after the operation of the power plant units. In addition to the above, the use of the L/ILW repository will continue. Making a plant part independent refers to the separation of certain functions, such as cooling or ventilation, from the systems of the power plant units to ensure the said plant parts to be made independent can function without the power plant units.
Cooling water	Cooling water is seawater used to cool the steam from the turbines back into water in a condenser. The water is then pumped back to the steam generators. Cooling water does not come into contact or mix with the process waters or primary and secondary system waters of the nuclear power plant.
International hearing	A hearing procedure in accordance with the Espoo Convention on the assessment of the transboundary environmental impacts, in which different countries can participate.
Intermediate-level waste	Nuclear waste with an activity level sufficiently high to require effective radiation shielding during the handling of the waste. The waste's activity concentration is usually between 1 MBq/kg and 10 GBq/kg. Intermediate-level waste is generated during both the operation and decommissioning of the power plant.
Light water reactor	A reactor type in which regular water is used for cooling and as a moderator. Most nuclear power plant reactors in the world are light water reactors.
Solidified waste	Liquid radioactive waste rendered into solid form by mixing it with a suitable binder (such as cement and other components).
Solidified waste hall	A hall in the L/ILW repository in which solidified waste is stored.
Solidification plant	A plant in which liquid radioactive waste is rendered into solid form by mixing it with a suitable binder. At Loviisa power plant's solidification plant, liquid waste is mixed with cement and other components.
Kilovolt (kV)	A volt (symbol V) is a derived unit of voltage in the SI system. 1 kV = 1,000 V.
Collective radiation dose	A collective (radiation) dose refers to the combined effective radiation dose of individuals exposed to radiation.
Contamination	Radioactive impurity.
Conventional	Normal, not related to radioactivity.
Conventional waste	Conventional and hazardous waste that is not radioactive.
Convergence measurement	The measurement of changes in the distance between fixed points. Often used to measure transformations in rock caverns.
Criticality	Criticality refers to a state in which the production and loss of the neutrons generated in fission and maintaining a chain reaction is in equilibrium so that the chain reaction continues smoothly.
Criticality safety	Criticality safety refers to the means and restrictions employed to control the criticality of a nuclear reactor and the prevention of super-criticality. The goal is to prevent the emergence of a geometric order of criticality or super-criticality.
Dry silo	A structure in the floor of the reactor hall consisting of 153 steel pipes. The steel pipes of the dry silo serve as a storage space for intermediate-level dry waste, such as any control rods' connection rods removed from use.
Dry waste handling facility	Areas in Loviisa power plant in which radioactive waste other than liquid radioactive waste is handled and packed.
Spent nuclear fuel	Nuclear fuel removed from the nuclear reactor after operation. Spent nuclear fuel contains fission products and is highly radioactive.

Interim storage for spent nuclear fuel	A water pool storage in the Loviisa power plant area in which high-level spent nuclear fuel removed from the reactor is stored. The interim storage consists of two water pool storages, KPA1 and KPA2. The spent nuclear fuel is transported from the interim storage to Posiva for encapsulation and final disposal.
Decommissioning	Dismantling a completely closed nuclear facility so that no special measures are needed in the plant area due to radioactive substances originating from the dismantled nuclear facility. Decommissioning also includes the handling, interim storage and final disposal of the low- and intermediate-level waste (decommissioning waste) accumulated in the dismantling of the plant. In addition, conventional dismantling waste may be generated in decommissioning.
Decommissioning waste	Waste generated in the decommissioning of a power plant or other nuclear facilities after operation that contains radioactivity and is deposited in the L/ILW repository for final disposal. See "dismantling waste".
LAeq	The midrange sound level over a particular period used to estimate the strength of fluctuating noise.
Littoral	The shore area.
Final disposal	The permanent disposal of radioactive waste in such a manner that the repository site does not need supervision, and the radioactivity of the waste does not pose a hazard to humans or the environment.
Final disposal facility	A nuclear facility designed for the final disposal of radioactive waste. Examples include the L/ILW repository.
Final disposal hall	A hall in the final disposal facility in which radioactive waste is stored/deposited for final disposal. In the L/ILW repository of Loviisa power plant, final disposal halls include maintenance waste halls and the solidified waste hall.
Loviisa nuclear power plant/ power plant	The nuclear power plant located on the island of Hästholmen in Loviisa, Finland, and the related functions and operations.
Mansievert (manSv)	The unit of a collective radiation dose.
Low-level waste	Nuclear waste with an activity level sufficiently low to allow its handling without any special radiation shielding measures. The waste's maximum activity concentration is usually 1 MBq/kg. Low-level waste is generated during both the operation and decommissioning of the power plant.
Millisievert (mSv)	A thousandth of the radiation dose unit sievert (see "sievert").
MW	Megawatt. A watt (W) is the unit of power and radiant flux in the SI system. 1 MW = 1,000,000 W.
Natura 2000	A nature protection programme of the European Union aiming to protect the core areas of the species and habitats listed in the Habitats Directive and Birds Directive.
Liquid waste storage	A hall at Loviisa power plant where liquid radioactive waste is stored.
Pressurised water plant	A light water reactor type in which water is used as a coolant and a moderator. The pressure of the water is kept so high that the water will not boil despite the high temperature. The water that has passed through the reactor core releases its heat into the secondary system water in separate steam generators, where the secondary system water is vaporised and used to drive a turbine.
Long-term safety	The safety of the final disposal of radioactive waste with regard to the radiation exposure of people and the environment after the final disposal facility has been closed. Depending on the activity of the waste, the timespan of the review can be from hundreds to hundreds of thousands of years.
Long-term safety case	A set of documents that demonstrates how the requirements concerning the long-term safety of the final disposal of nuclear waste are met.
Fuel integrity	A situation in which a fuel rod remains intact and does not release any radioactive substances. Fuel failure refers to a situation in which a fuel rod loses its integrity.
PRA	Probabilistic Risk Assessment.
Primary system	A cooling system for removing heat from an energy source such as a reactor core.
Process wastewater	Wastewater generated in the power plant process.
Dismantling waste	An overall concept for waste generated in connection with the decommissioning and dismantling of nuclear facilities. Dismantling waste includes both decommissioning waste that contains radioactivity and non-radioactive conventional waste.

Radioactive substance	A substance that decays into other substances and concurrently emits ionising radiation.
Radioactive waste	Radioactive waste refers to radioactive substances and equipment, goods or materials contaminated by radioactivity that are not required and that must be rendered safe because of their radioactivity.
Reactor pressure vessel	A vessel able to withstand internal pressure in which the reactor is located. Text
SAC	A Special Area of Conservation related to the Natura 2000 programme.
SCI	A Site of Community Importance related to the Natura 2000 programme.
Secondary system	A cooling system for removing heat from the primary system.
Sievert (Sv)	The unit of radioactive dose that represents the effect of radiation on the human body. Fractions of it include a millisievert (mSv), which is a thousandth of a sievert, and a microsievert (μSv), which is a millionth of a sievert.
SPA	A Special Protection Area pursuant to the Birds Directive and related to the Natura 2000 programme.
STUK	The Radiation and Nuclear Safety Authority, which is the authority supervising safety in Finland, a research institution and an expert organisation.
Control rod **Control rod's absorber element** **Control rod's connection rod**	Control rod: A moveable component between the fuel bundles or fuel rods in the reactor core used to control the core's reactivity. The control capability of the control rods is based on their neutron-absorbing quality. Control rods are usually grouped into the control rods used for a reactor trip in the reactor and the rods used for the control of the reactor during operation. In big reactors, the controlling rods are further divided into several groups fulfilling a different role in the control. Absorber element (neutron absorber): A medium or object which absorbs free neutrons. Control rods are neutron absorbers, and their insertion into the reactor core reduces reactivity. The control rod of a VVER-440 reactor is composed of an absorber element and fuel extension connected to one another with a connection rod. The absorber is located on top of the fuel extension. The absorber is tasked with absorbing neutrons and thereby reducing reactivity when a control rod's absorber element has been inserted into the reactor core.
Sanitary wastewater	Wastewater that originates from the toilets, kitchens, washrooms of residences, offices, buildings and institutions, as well as equivalent areas and equipment, and from business operations.
Targeted dose constraint	A nuclear power plant must have dose constraints in place that are lower than those provided in the Radiation Decree.
MEAE	The Ministry of Economic Affairs and Employment. The coordinating authority (liaison authority) in the environmental impact assessment procedure.
Thermocline	A layer in a body of water in which the water's temperature drops rapidly.
Terabecquerel	A unit of radioactivity; see "becquerel".
Transuranic elements	Transuranic elements, i.e. substances heavier than uranium, generated in U-238's neutron captures, for example. In normal situations, transuranic elements remain within the protective cladding of a fuel rod, but in connection with fuel rod leaks, they may be released into the plant's systems.
TWh	Terawatt-hour. A unit of energy used to express the amount of energy, electricity and heat produced.
Hazardous waste	Hazardous waste includes decommissioned substances or items that may cause special danger, or harm to health or the environment. Hazardous waste includes energy-saving lightbulbs and other fluorescent lights. The former term in Finnish was 'ongelmajäte'.
Clearance from regulatory control	If waste generated in the radiation controlled area does not exceed the limits set by the authorities, it can be cleared from regulatory control. Waste cleared from regulatory control can be handled as conventional waste.
Radiation controlled area	A radiation controlled area refers to a work area where special safety guidelines must be observed to ensure radiation protection. Access to radiation controlled areas is controlled. At a minimum, those rooms in the facility where the external dose rate can exceed 3 μSv/h or where a 40-hour weekly stay can cause an internal dose in excess of 1 mSv per year due to the radionuclides originating from a nuclear facility must be designated as controlled areas. (YVL Guide C.2)

Clearance limits	The limit value, expressed as an activity concentration, at the level of or below which materials generated in operations subject to a licence may be cleared from regulatory control.
Release barrier	A technical or natural structure or material that provides long-term safety functions – in other words, prevents radioactive substances from being released into the environment.
L/ILW repository	Loviisa power plant's final disposal facility for low- and intermediate-level waste. The abbreviation L/ILW stands for 'low- and intermediate-level waste'. The English translation 'operational waste' is used for both Finnish terms 'voimalaitosjäte' (an obsolete term) and 'ydinlaitosjäte'.
Power plant area	The area used by the nuclear power plant units and other nuclear facilities in the same area, or the area surrounding them, where moving and staying is restricted by a decree of the Ministry of the Interior issued by virtue of Chapter 9, section 8 of the Police Act (872/2011) (STUK Y/2/2018). The Loviisa nuclear power plant area covers the islands of Hästholmen and Tallholmen and their adjacent sea area, the Kirmosund causeway and the main gate building.
VTT	VTT Technical Research Centre of Finland Ltd.
Seepage water	Groundwater that accumulates in a shaft or tunnel built or excavated in the bedrock. At Loviisa power plant, seepage waters are generated in the L/ILW repository.
WANO	World Association of Nuclear Operators
Weser	What is commonly referred to as the Weser case (C-461/13) involves a ruling of the EU Court of Justice related to the river Weser in Germany, in which the Court adopted the view that the environmental objectives of water resources management were legally binding in licensing considerations concerning projects. According to the Weser ruling, licences may not be issued to projects which may have adverse effects on the state of a body of surface water.
Nuclear material	Specific fissionable materials suitable for generating nuclear energy, such as uranium, thorium and plutonium.
Nuclear waste	A generic term for the radioactive waste generated in connection with, or as a consequence of, the operation or decommissioning of a nuclear facility. Nuclear waste is low-level or intermediate-level waste or high-level spent nuclear fuel.
Nuclear facility	A nuclear facility refers to plants used to generate nuclear energy, including research reactors, facilities carrying out extensive final disposal of nuclear waste, as well as facilities used for the extensive production, use, handling or storage of nuclear material and nuclear waste. For example, at Loviisa nuclear power plant, once the power plant units have been decommissioned, the nuclear facility will consist of plant parts to be made independent.
Operational waste	Low- and intermediate-level waste generated in nuclear facilities, such as nuclear power plants. For example, operational waste is generated in the handling of radioactive liquids and gases, and in maintenance and repair work carried out in the radiation controlled area.
Nuclear fuel	Uranium (or plutonium) intended to be used in the reactors of nuclear power plants. Nuclear fuel does not burn in the sense that it would react with oxygen (as happens when coal or wood is burned); instead, heat is produced when the nuclei of uranium are split in chain reactions. The 'combustion products' are isotopes of lighter elements generated in the chain reaction. Most are radioactive. The uranium in the nuclear fuel used by Loviisa power plant is in the form of uranium oxide (UO_2).
Nuclear power plant	A nuclear power plant refers to a nuclear facility, equipped with a nuclear reactor, used to generate electricity or heat, or a plant complex formed by power plant units and other associated nuclear facilities in the same location. A nuclear power plant comprises one or more nuclear power plant units, each of which has one reactor, and one or two turbines and generators.
Nuclear power plant unit/ power plant unit/plant unit	Loviisa power plant consists of two nuclear power plant units, Loviisa 1 and Loviisa 2.
Coordinating/liaison authority	The Ministry of Economic Affairs and Employment is the coordinating/liaison authority in this EIA procedure.
ME	The Ministry of the Environment. Serves as the coordinating authority for the international hearing in Finland.
EIA	Environmental impact assessment
YVL Guides	Nuclear safety guides; regulatory guides published by the Radiation and Nuclear Safety Authority that specify the detailed safety requirements for the use of nuclear energy.

APPENDIX 1

EIA Report Experts

The Environmental Impact Assessment Report was prepared jointly by Ramboll Finland Oy and Fortum Power and Heat Oy, the project owner. The following experts took part in the preparation of the report:

Expert	Duties and qualification
Antti Lepola **Project director**	**M.Sc. (Agriculture and Forestry) (forestry planning)** Lepola has 30 years' experience in environmental research and planning. His core competence areas include the environmental impact assessment of projects, water, environmental and chemical permit applications, as well as related surveys. Lepola has long experience of environmental consulting related to energy production and the environmental impact of the industry. Lepola has participated in more than 70 EIA procedures and worked as a project manager in more than 30 EIA procedures.
Anna-Katri Räihä EIA project manager and expert (subconsultant)	**M.Sc. (Agriculture and Forestry) (environmental economics)** Räihä has more than 10 years' experience in environmental consulting and project management related to the environmental projects of several fields of industry. Her core competence includes environmental impact assessments, international hearings in the EIA, environmental legislation and greenhouse gas calculations. Räihä has worked as a project manager and project coordinator in several extensive EIA procedures, and as an expert in environmental issues in numerous EIA procedure impact assessments (including greenhouse gas emissions and their impact on the environment, traffic impact, impact of the use of natural resources). Her EIA competence also includes various areas of communication and stakeholder engagement.
Sanna Sopanen EIA coordinator, surface waters	**Ph.D. (aquatic ecology)** Sopanen has extensive experience of surveys related to the quality of surface waters and the aquatic environment, spanning 20 years. Her special expertise is related to the interactive relationships in the aquatic ecosystem, and the factors affecting them in both inland waters and sea areas. Sopanen has participated in numerous environmental impact assessments (EIA), licensing and land use planning projects, nature surveys, Natura assessments and various water system surveys as an expert on the impact on water systems.
Mikko Happo Health impacts	**Ph.D. (environmental health); docent (toxicology of combustion emissions)** Happo's job description includes expert tasks related to air quality as well as development tasks in air quality and health services. In addition, his duties include expert services related to the environmental and health sector and its reporting concerning air quality, emissions into the air, or other environmental and health impacts.
Anne Kiljunen Air quality	**M.Sc. (inorganic and analytical chemistry)** Kiljunen works as an environmental expert and has seven years' experience of various environmental expert tasks related to air quality. She has experience of various tasks in the field, the reporting of measurements, preparation of environmental permit applications and environmental impact assessments.
Kirsi Koivisto Vibration	**M.Sc. (Tech.) (foundation engineering and soil mechanics)** Koivisto has worked in the field of vibration inspections and studies for more than 10 years. She has extensive experience in the methods used in Finland to dampen vibration and in carrying out various vibration inspections. Koivisto's area of specialisation includes planning, studying and development of dampening methods, as well as assessing the impact of vibration.
Heini Koutonen Greenhouse gas emissions	**M.Sc. (Agriculture and Forestry) (environmental economics)** Koutonen works as an environmental consultant in diverse projects related to climate impact assessments, emission calculations, lifecycle assessments and material flow analyses. She specialises in the calculation of greenhouse gas emissions and carbon sinks, and in her previous jobs, has prepared carbon neutrality roadmaps, climate impact assessments and emission calculations at product, corporate, project and regional levels.
Timo Laitinen Landscape and land use	**M.Soc.Sc. (social and economic geography)** Laitinen has more than six years' experience of EIA procedures and related impact assessments. He has participated in approximately 30 EIA procedures as an appraiser of impacts (landscape and cultural environment, land use and land use planning) and worked as a coordinator in ten EIA procedures.
Otso Lintinen Ichthyofauna and fishing	**M.Sc. (Agriculture and Forestry) (fishing industry)** Lintinen works as a project manager in various projects related to water research. He has 11 years' experience of corresponding tasks. His area of specialisation is studies concerning the fishing industry.

Expert	Duties and qualification
Timo Metsänen Avifauna (subconsultant)	**Bachelor of Natural Resources, Environmental Planning, nature planner (special vocational qualification)** Metsänen has more than 20 years' experience of various avifauna surveys. He works as a subconsultant for Ramboll Finland in the project (Tmi Luontoselvitys Metsänen).
Juho Mäkelä waste management	**B.Sc. (Engineering) (environmental technology** Mäkelä has more than five years' experience of tasks related to material efficiency, waste management and earth construction. He works as a planner in projects related to the utilisation of materials. He has also worked as an independent quality controller in earth construction projects that require an environmental permit.
Jussi Mäkinen Nature and avifauna	**M.Sc. (environmental ecology)** Mäkinen has 16 years' experience of aligning natural values and the planning of land use in various land use planning and construction projects. Mäkinen specialises in the impact assessments of projects with considerable environmental impacts and the preparation of the required nature and environmental surveys. Mäkinen is one of Finland's leading experts in matters related to the Natura 2000 network (assessments, deviation procedures). His other areas of specialisation include ecological network surveys, ecological compensation, exemption permit applications, as well as various species surveys concerning avifauna especially.
Ville Mäntylä Dismantling operations	**Architectural drafter** Works as a project manager and harmful substance expert in projects related to construction. He has 18 years' experience of corresponding tasks. His areas of specialisation include dismantling consultation projects, as well as asbestos and harmful substance surveys.
Pekka Onnila Groundwater, soil and bedrock	**M.Sc. (soil science)** Onnila has extensive experience of the assessment of groundwater risks and impacts related, for example, to EIA projects, land use planning and environmental permits. In addition, Onnila is responsible for groundwater monitoring related to various functions and forms of land use.
Venla Pesonen Social impacts	**M.Sc. (environmental science); B.Sc. (Engineering) (environmental technology)** Pesonen works as an interaction designer in the interaction team of the land use unit. She has several years of diverse experience of the assessment of impacts targeting people, planning and implementation of stakeholder engagement, the facilitation of events, as well as methods of interactive information gathering, analysis and reporting in various projects.
Arttu Ruhanen Noise	**B.Sc. (Engineering) (environmental technology)** Ruhanen has more than 10 years' experience of the preparation of environmental studies. Every year, he works in several dozen projects as a planner or project manager studying noise. Ruhanen's special expertise in matters related to noise focuses on the industry, noise studies in the mineral aggregate operations and wind power, as well as various noise measurements.
Tiina Sainio Traffic	**M.Sc. (Engineering) (structural engineering)** Sainio has more than five years' experience in the preparation of traffic studies. She works as a principal planner in various projects involving traffic studies and planning. Sainio specialises in traffic safety as well as the transport and traffic planning of streets and various industrial and service sites.
Heikki Savikko Regional economy	**M.Sc. (Engineering) (materials technology, industrial economics)** Savikko has experience in impact and materiality assessments, the modelling of economic impacts as well as materials and resource efficiency, and of work related to lifecycle assessments. Among other things, he has modelled cash, resource and material flows at the national, regional and corporate levels, and formed links from resource flows to environmental and economic data. He has also participated in the development of indicators and assessment means for resource efficiency and the wise use of resources.

Expert	Duties and qualification
Jarkko Ahokas	**M.Sc. (Engineering) (energy technology)** Nuclear safety
Nici Bergroth	**M.Sc. (Engineering) (process technology)** Nuclear technology and safety
Tapani Eurajoki	**M.Sc. (Engineering) (nuclear and energy technology)** Nuclear waste, long-term safety, external waste
Mika Harti	**M.Sc. (Engineering) (energy technology)** Nuclear safety
Juha-Pekka Jurvanen	**M.Sc. (Meteorology)** Preparedness measures, dispersion of cooling water
Matti Kaisanlahti	**M.Sc. (Engineering) (energy technology)** External waste
Laura Kekkonen	**M.Sc. (Engineering) (nuclear technology)** Procurement of nuclear fuel, spent nuclear fuel
Pasi Kelokaski	**M.Sc. (Radiochemistry)** Decommissioning of the power plant
Markku Lahti	**D.Sc. (Technology) (water economy and hydrology)** Hydrology and environmental impacts, cooling water modelling
Jesse Lavonen	**Bachelor (Engineering; amk) (energy and environmental technology)** Decommissioning of the power plant, external waste
Maria Leikola	**D.Sc. (Technology) (materials technology)** Decommissioning of the power plant
Joni Niiranen	**Bachelor (Engineering; amk) (environmental technology)** Loviisa power plant's EHS expert, The power plant's environmental perspectives
Satu Ojala	**M.Sc. (Limnology)** The power plant's perspectives related to waterway
Maiju Paunonen	**Bachelor (Engineering; amk) (environmental technology)** Spent nuclear fuel, storage and final disposal
Anu Ropponen	**M.Sc. (Engineering) (environmental technology)** The power plant's environmental perspectives
Tommi Ropponen	**Ph.D. (Physics)** Radiation safety, accidents
Teemu Seitomaa	**M.Sc. (Engineering) (energy technology)** Decommissioning of the power plant

APPENDIX 2

Report of the Ministry of Economic Affairs and Employment on the environmental impact assessment programme of Loviisa nuclear power plant

On 13 August 2020, Fortum Power and Heat Oy submitted to the Ministry of Economic Affairs and Employment an assessment programme (EIA programme) in accordance with the Act on the Environmental Impact Assessment Procedure (252/2017). The assessment programme concerns the continuation of the operation of Loviisa Nuclear Power Plant for a maximum of approximately 20 years after the expiry of the current operating licences, after which the nuclear power plant would be decommissioned. Alternatively, Loviisa Nuclear Power Plant could already be decommissioned after the operating licences already in force have ended.

1. Environmental impact assessment procedure and project information

The aim of the Act on the Environmental Impact Assessment Procedure (EIA) is to promote the environmental impact assessment and the uniform integration of assessments into planning and decision-making, while also increasing access to information and participation for all.

The assessment programme is the plan of the party responsible for the project for the necessary studies and the organisation of an assessment procedure for the assessment of environmental impacts. The assessment programme shall contain information on the project, its options and a description of the current state of the environment. Section 3 of the Government Decree on the EIA procedure (277/2017, EIA Decree) lays down the information contained in the programme and the information presented therein.

In the next phase of the EIA procedure, the party responsible for the project shall prepare a report on the environmental impact assessments on the basis of the assessment programme and the statement of the liaison authority. The liaison authority shall communicate the statement by means of a public notification, inform at least one of the newspapers generally circulating in the area covered by the project, request opinions on the report and reserve the possibility for the expressing of opinions. After reviewing the adequacy and quality of the assessment report, the liaison authority shall prepare a reasoned conclusion on the significant environmental impact of the project and communicate it by means of a public notification. The environmental impact assessment report and reasoned conclusion shall be attached to any projects for authorisation under the Nuclear Energy Act (990/1987).

According to section 10 of the EIA Act, the Ministry of Economic Affairs and Employment acts as the joint authority for projects concerning nuclear facilities referred to in the Nuclear Energy Act.

1.1 PARTY RESPONSIBLE FOR PROJECT

The party responsible for the project is Fortum Power and Heat Oy (Fortum). Ramboll Finland Oy has acted as a consultant for Fortum Power and Heat Oy in the environmental impact assessment.

1.2 THE PROJECT AND ITS OPTIONS

The assessment programme concerns the continued operation and, alternatively, the decommissioning of Loviisa Nuclear Power Plant. The valid operating licences for the Loviisa 1 and Loviisa 2 Nuclear Power Plant units and their buildings and storages necessary for the management of nuclear fuel and nuclear waste will expire in 2027 and 2030. The programme also deals with the use of a low- and medium-level nuclear waste disposal facility (VLJ repository). The valid operating licence for the VLJ repository expires in 2055. The programme examines three different options for further operations.

Under option 1 (VE1), the company would continue to use the Loviisa 1 and 2 Nuclear Power Plant units for a maximum of approximately 20 years after the current operating licences have ended. The use of buildings and storages necessary for the maintenance of nuclear fuel and nuclear waste from the Loviisa 1 and 2 Nuclear Power Plant units would also continue with the necessary extensions. It would also be possible to process, intermediately store and dispose of small amounts of radioactive waste generated elsewhere in Finland at the nuclear power plant.

Under option 0 (VE0), the nuclear power plant would be decommissioned at the end of the existing operating licences. Buildings and storages necessary for the maintenance of nuclear waste from plant units would continue to be used until they become redundant and decommissioned.

Option 0+ (VE0+) is, otherwise, the same as option 0, but it would also be possible to process, intermediately store and dispose of small amounts of radioactive waste generated elsewhere in Finland at the nuclear power plant.

1.3 PROJECT RELATION TO OTHER PROJECTS

According to the assessment programme, the project is not directly related to other projects currently underway or planned at Loviisa Nuclear Power Plant.

The spent fuel of Loviisa Nuclear Power Plant is to be transferred to Posiva Oy's spent fuel disposal facility in Olkiluoto. The project will, therefore, have an impact on Posiva Oy's spent fuel disposal facility and the amount of spent nuclear fuel transferred there.

The assessment procedure examines various options that include the possibility of processing, intermediate storing and disposing of small amounts of radioactive waste generated elsewhere in Finland. In other words, the project is also related to projects in other parts of Finland that are typically carried out by industry, health care and research institutes, which result in the development of the aforementioned low- and medium-level waste.

The project is also related to decommissioning projects of VTT Oy's FiR 1 research reactor and the radioactive structural materials research laboratory located in Otakaari 3 (OK3). The assessment procedure takes into account the possible intermediate storage of low- and medium- level demolition waste from decommissioning projects at Loviisa Nuclear Power Plant and the final disposal in the VLJ repository. In addition, the procedure provides for the intermediate storage of spent and unused nuclear fuel from the FiR 1 research reactor at Loviisa Nuclear Power Plant. Intermediate storage would continue until VTT Technical Research Centre of Finland Ltd proceeds in the further preparation of nuclear fuel.

The project may relate to various plans and programmes for the use of natural resources and environmental protection, such as national target programmes and international commitments.

The programme states that, in the future, the project may have an impact on the further use of existing power lines and on the possible utilisation of thermal energy (waste heat) produced by the plants, but their examination has been excluded from the current assessment procedure.

2. Licence procedures

The operation and decommissioning of a nuclear facility requires a licence in accordance with the Nuclear Energy Act. The licences are issued by the Government. The project may also require other licences granted by the STUK Radiation and Nuclear Safety Authority in accordance with section 21 of the Nuclear Energy Act.

The valid operating licences for the plant units of Loviisa Nuclear Power Plant will expire in 2027 (Loviisa 1) and 2030 (Loviisa 2). The valid operating licences for buildings and warehouses and their extensions for nuclear fuel and nuclear waste needed for the management of nuclear fuel and nuclear waste in plant units will expire in 2030. The valid operating licence of the nuclear power plant waste disposal facility (VLJ repository) expires in 2055.

If the party responsible for the project wishes to continue using nuclear power plant units, new operating licences must be applied for said plant units. Otherwise, a licence must be sought for the decommissioning of the nuclear facility. If the party responsible for the project wishes to use the VLJ repository for a longer period of time than the valid licence allows, this also requires applying for a new operating licence. Due to the longer operating time than the VLJ nuclear power plant units, it is practical to separate the VLJ repository licence into a separate licence decision.

Other possible licences discussed in the assessment programme include permits in accordance with the Land Use and Building Act (132/1999), an environmental permit in accordance with the Environmental Protection Act (527/2014), a water management permit in accordance with the Water Act (587/2011) and permits in accordance with the Chemicals Act (390/2005). The above acts also involve different notification obligations.

The existing local detailed plan for the area makes it possible to implement the options set out in the assessment programme.

2.1 ENVIRONMENTAL IMPACT ASSESSMENT

Fortum Power and Heat Oy submitted the assessment programme to the Ministry of Economic Affairs and Employment on 13 August 2020. The submission of the assessment programme triggered the EIA procedure.

Fortum Power and Heat Oy shall prepare an environmental impact assessment report on the basis of an assessment programme and an opinion issued by the liaison authority. The company has estimated that it will submit the report to the liaison authority in the autumn of 2021.

The project is also subject to an intergovernmental assessment procedure for possible cross- border environmental impacts. In the procedure, the so-called Opportunity for States covered by the Espoo Agreement (67/1997) and their citizens to participate in the environmental impact assessment procedure is reserved. The Ministry of the Environment is responsible for the organisation of the international consultation.

2.2 OPERATING LICENCES

The use of nuclear power plant units and the buildings and warehouses necessary for their operation and the maintenance of nuclear waste, as well as the use of the VLJ repository, require government-issued operating licences as provided for in section 20 of the Nuclear Energy Act.

The licence to operate a nuclear facility requires due consideration of the safety requirements of the Nuclear Energy Act, the safety of workers and the population, as well as the protection of the environment. The applicant shall have, at their disposal, adequate and appropriate methods for arranging nuclear waste management and, at their disposal, the necessary expertise. The applicant is considered to have the financial and other necessary conditions to carry out operations safely and in accordance with Finland's contractual obligations. In addition, the nuclear facility and its use must meet, among other things, the principle of the overall interest of society.

2.3 DECOMMISSIONING LICENCE

After discontinuing the operation of a nuclear facility, the holder of a licence, in accordance with section 20 of the Nuclear Energy Act, is obliged to initiate measures to decommission the nuclear facility. Decommissioning is carried out in accordance with the plan and requirements referred to in section 7g of the Nuclear Energy Act. In addition, the licence holder must apply for a licence for the decommissioning of a nuclear facility. The licence shall be applied for in sufficient time so that the authorities have adequate time to evaluate the application before the end of the operating licence of the nuclear facility. The assessment programme provides two alternative times for decommissioning. In option 1, the decommissioning would take place between 2050 and 2060

In options 0 and 0+, decommissioning would take place already between 2030 and 2040.

The licence for the decommissioning of a nuclear facility requires, among other things, due account to be taken of safety requirements under the Nuclear Energy Act, the safety of workers and the population, as well as environmental protection.

3. Information and consultation on the assessment programme

The Ministry of Economic Affairs and Employment announced the assessment programme in accordance with the EIA Act and Decree in the areas affected by the project and organised a consultation on the matter. As of 27 August 2020, the consultation was announced on the websites of the Ministry and the municipalities of the affected area, as well as in the following newspapers: Helsingin Sanomat, Hufvudstadsbladet, Kymen Sanomat, Loviisan Sanomat, Uusimaa, Itäväylä, Östnyland and Nya Östis. The EIA programme was available to view during 27 August-26 October 2020 on the website of the Ministry of Economic Affairs and Employment.

Together with the responsible party to the project, the Ministry organised a public event in Loviisa on 3 September 2020. Six people attended the public event on site and about 50 people online.

The Ministry of Economic Affairs and Employment requested opinions on the assessment programme from the Ministry of the Environment, Ministry of the Interior, Ministry of Foreign Affairs, Ministry of Defence, Ministry of Agriculture and Forestry, Ministry of Transport and Communications, Ministry of Social Affairs and Health, Ministry of Finance, Radiation and Nuclear Safety Authority, Regional State Administrative Agency of Southern Finland, Uusimaa ELY Centre, Helsinki-Uusimaa Regional Council, Finnish Safety and Chemicals Agency Tukes, Finnish Environment Institute, Eastern-Uusimaa Emergency Services Department, Eastern Uusimaa Police Department, City of Loviisa, Municipality of Myrskylä, Municipality of Pyhtää, City of Porvoo, Municipality of Lapinjärvi, City of Kouvola, AKAVA ry, Confederation of Finnish Industries EK, Finnish Energy ET, Geological Survey of Finland, Greenpeace, Fennovoima Oy, Fingrid Plc, The Central Union of Agricultural Producers and Forest Owners (MTK), Finnish Heritage Agency, Natur och Miljö rf, Posiva Oy, VTT Technical Research Centre of Finland, Teollisuuden Voima Oyj TVO, Finnish Confederation of Finnish Industries STTK, Finnish Association for Nature Conservation, Suomen Yrittäjät ry, Central Organisation of Finnish Trade Unions SAK ry and WWF.

In addition to those mentioned, other parties and citizens have also had the opportunity to express their views on the project. The opinions and considerations that were expressed concerning the EIA programme are summarised in section 4.

In a request for action sent on 25 August 2020, the Ministry of Economic Affairs and Employment asked the Ministry of the Environment to organise an international consultation in accordance with the Espoo Agreement in connection with the EIA procedure of Loviisa Nuclear Power Plant and to forward the feedback received to the EIA liaison authority (Ministry of Economic Affairs and Employment) for consideration in its opinion on the EIA programme.

On 27 August 2020, the Ministry of the Environment sent a notification of the project to Sweden, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Norway and Russia. In addition, all other parties to the Espoo Agreement were informed about the project's EIA procedure. Austria and the Netherlands replied that they wished to receive the notification provided to them under the Espoo Agreement.

The alert, the EIA programme and the statements and opinions received during the consultation period can be found on the website of the Ministry of Economic Affairs and Employment at https://tem.fi/en/loviisa-1-and-2-eia-programme.

4. Summary of statements and opinions

A total of 39 statements and opinions of the national consultation were submitted to the ministry. The Finnish Heritage Agency announced that it had forwarded the request for a statement to the regional museum of responsibility of Eastern Uusimaa (Porvoo Museum). The following organisations did not respond to a request for comment: the Ministry of Defence, Ministry of Transport and Communications, Ministry of Social Affairs and Health, Finnish Environment Institute, Municipality of Myrskylä, City of Kouvola, AKAVA ry, Confederation of Finnish Industries, Finnish Energy, The Central Union of Agricultural Producers and Forest Owners (MTK), Suomen Yrittäjät ry, WWF.

In the statements, the assessment programme is considered to be largely comprehensive. However, the parties behind the statements made some individual comments that should be taken into account and assessed in the EIA procedure. Comments were received, especially, on the water impacts of the nuclear power plant and accident modelling.

The statements also commented on the project options set out in the programme. Several agents behind the statements said they were in favour of continuing the use of the nuclear power plant based on climate objectives and economic factors, among other things. Support for decommissioning was generally justified by the abandonment of nuclear energy or by the fact that the Loviisa plants are already old. On the other hand, modernisations also appeared in the statements. In international consultation under the Espoo Agreement, Sweden, Estonia, Russia, Norway, Denmark, Lithuania, Germany and Austria have announced that they will participate in the EIA procedure for the project. Latvia and Poland do not consider themselves to be target parties and will not participate in the EIA procedure. However, the countries wish to be informed of the assessment report. A total of 20 statements were received from EU citizens and organisations. The international consultation highlighted the risks of a serious nuclear accident and its consequences.

Bulgaria, Canada, Greece, Romania and Hungary replied to the information sent on the pending employment of the EIA procedure. The countries do not consider themselves to be target parties and it is, therefore, not necessary to continue the procedure laid down in the Espoo Agreement. Romania and Hungary request to be notified of the assessment report.

The statements and opinions are available on the website of the Ministry of Economic Affairs and Employment.

4.1 REQUESTED STATEMENTS OF AUTHORITIES

4.1.1 Ministry of Agriculture and Forestry

The Ministry of Agriculture and Forestry states that the effects of climate change should have already been taken into account in the assessment programme. Taking climate change into account is especially relevant if operations in Loviisa are discontinued. The Ministry recalls that the taking into account of the risks of climate change must be continuously developed and promoted in projects that, due to the nature of the operations and the long life of the operations, involve specific climate risks.

The Ministry notes that the programme had only addressed flooding as a risk posed by climate change. However, Loviisa is already a significant flood risk area, which should be taken into account in the programme. In addition, according to the Ministry, the programme should examine the possible adverse effects on fish, fisheries and marine mammals in accordance with the precautionary principle. For example, activities should be avoided in spawning and occurrence areas important for fish stocks.

4.1.2 Geological Survey of Finland (GTK)

The Geological Survey of Finland (GTK) states that under the terms of the environmental permits, a maximum temperature for cooling water returning to the sea has been set, which must not be exceeded. According to GTK, the assessment procedure should examine how an extension of 20 years of use, combined with the warming of seawater caused by climate change, will affect compliance with the permit conditions. This may have an impact on the production of the power plant and on any need to change the cooling water system as referred to in the programme.

The disposal of decommissioning waste requires a significant expansion of the VLJ repository. The extent of excavations resulting from the continued use of plant units is not sufficiently clear in the EIA programme.

GTK points out that the assessment should consider the need to update the Hästholmen rock model, especially from the point of view of water-leading structures. The moderately high need for expansion of the VLJ repository will probably increase the occurrence of water leaks and the amount of water pumped into the sea. In order to reliably estimate the volume and effects of increasing pumping, the design of the expansion (e.g. positioning and possible injection design) must be based on up-to-date structural geological and hydrogeological data.

In GTK's view, it is important to examine how the options presented affect the need to update environmental impact monitoring programmes. GTK highlights, in particular, the change in rock groundwater conditions due to the expansion of the VLJ repository. In addition, by 2060 or 2080, changes in the baseline may result from global warming, changes in precipitation and a shortening winter season. These may require increased monitoring for both the environment and the operation of the independent plant components.

4.1.3 Eastern-Uusimaa Emergency Services Department

The Eastern-Uusimaa Emergency Services Department states that it will draw up an external emergency plan for the nuclear facility together with the operator. In the case of decommissioning, the Emergency Services Department shall maintain an emergency plan and organise statutory preparedness exercises until the site no longer poses a particular risk under section 48 of the Rescue Act (379/2011).

The Emergency Services Department states that in the project options, the operator must comply with the licence conditions and requirements set by STUK and the Finnish Safety and Chemicals Agency with regard to emergency arrangements. Upon request, the Emergency Services Department issues statements to the responsible authorities in matters in accordance with the steering obligation of the rescue services.

When applying for a decommissioning licence, the licence applicant must submit a plan regarding security and preparedness arrangements to STUK. If necessary, the Emergency Services Department will issue statements on the above plans concerning the implementation of the operating conditions for rescue operations.

4.1.4 Eastern Uusimaa Police Department

The Eastern Uusimaa Police Department says it will mark the project for information and take into account its impact on policing in accordance with their legislation. In its statement, the police department explains its own responsibilities, including regular planning and review of various preparedness and security arrangements and traineeships in cooperation with other security authorities. The police department emphasises the importance of regular and practical cooperation to prevent various threats and incidents between different authorities, operators and power plant personnel.

With regard to threats, the police department highlights e.g. the National Counter-Terrorism Strategy 2018–2021, which addresses the possible attempt by terrorist activities to exploit nuclear weapons or other radioactive substances. In addition, the police department points out that preparing for major accidents requires education, training and advance plans

4.1.5 Porvoo Museum

Porvoo Museum considers that the studies described in the programme are sufficient to assess the impact of the alternatives on the cultural environment and landscape of the area. The museum highlights, among other things, the cultural environment and relic area of the nationally significant Svartholma fortress, as well as the provincially significant western and southern parts of Gäddbergsö and the water area between them.

4.1.6 Radiation and Nuclear Safety Authority

According to STUK, the assessment programme meets the criteria of the EIA safety programme laid down in section 16 of the Nuclear Safety Act. STUK will assess the fulfilment of safety- related requirements in detail in connection with the processing of an application for a licence for use or decommissioning. Anticipating the future licencing process, STUK expects the responsible party to the project to supplement some areas in the assessment report and the studies in accordance with the assessment programme.

According to STUK, the report should address the application of the BAT principle to emission reductions. New solutions and procedures, known or planned, should be addressed, at least under option 1.

STUK states that it is not clear from the assessment programme which substances are included in the study of harmful substances in sediments on the seabed. STUK requires that the amounts of artificial radioactive substances in sediments in a possible dredging area be investigated and the impact of their possible release on the environment be assessed in connection with dredging work. According to STUK, the effects of changes in flow fields on the transport of radioactive substances from the discharge opening should also be investigated in cooling water modelling that takes into account the new embankment structure and in expert assessments based on it.

Nuclear fuel used in option 1 is generated more than has been taken into account in the licence process and decisions of the Posiva final disposal project. In the assessment report, it would be a good idea to assess whether the spent fuel generated in connection with option 1, i.e. further use, has an impact on the decisions of principle and the construction licence granted to Posiva.

The EIA report should also indicate the estimated amount of activity of waste coming from other parts of Finland to the Loviisa power plant, the composition of the nuclides and the physical/chemical state of radioactive substances.

In addition, STUK points out that section 3.1 refers to the activity limits set by the authority for water emissions. However, the authority, STUK, has not set any limits, but has established the limits proposed by the licence holder in accordance with section 7c of the Nuclear Energy Act.

4.1.7 The Centre for Economic Development, Transport and the Environment of Uusimaa (Uusimaa ELY Centre)

Uusimaa ELY Centre states that the assessment programme appears to be properly prepared and that the descriptions of the current state of the project and the environment are comprehensive. The ELY Centre proposes supplements to the following points, among others.

According to the ELY Centre, the studies carried out to assess the impacts must be described with sufficient accuracy, which was not achieved in the case of impacts on surface waters. The study of harmful substances in sediments, the impact of waterworks on flow conditions and the methods used in the assessment e.g. to assess underwater noise should have been described in more detail. The description of cooling water modelling should also be specified, e.g. with regard to starting assumptions and sensitivity analysis. The effects of the different options on the water quality and ecological status of Lake Lappominjärvi must be assessed.

The ELY Centre points out that the assessment report should present a model of soil, bedrock and groundwater conditions based on the latest studies, as well as an assessment of the leakage water accumulated in rock spaces. The information on the studies used should be specified in the report. Information on nearby wells, including heating wells, should be updated regularly.

The statements highlight the negative impact on fisheries of the continued operation of the power plant and the related water construction. The programme should examine the effects of condensing waters on both alien species and existing species more extensively than is presented.

According to the ELY Centre, it is important to describe the climate impacts of the project in the assessment report as a separate item, the effects of construction and decommissioning, as well as the long-term effects. As regards the climate impact assessment, it should be specified whether the effects of the nuclear fuel production chain and spent fuel disposal are included in the review. It would be a good idea to relate the direct climate impacts of project options, not only to national climate objectives but also to regional objectives. The report should set out the impact of continued use on the structure and emissions of domestic electricity production. The risks posed by climate change to the operation of the nuclear power plant should also be described in the statement.

The ELY Centre requests clarifications on the environmental and water permits required for the project. For example, in the case of the cessation of water intake, the removal of structures for water intake requires a permit in accordance with the Water Act, which was not mentioned in the programme.

The opinion states that the impact of transportation and the assessment of noise and vibration effects should also be specified. The ELY Centre makes various comments related to, among other things, participation in pandemic arrangements, the affected area and exposed residents, the entry into force of the Uusimaa phase county plan, the utilisation of quarrying from the expansion of the VLJ repository and the sites of contaminated soil. In addition, the assessment report should clarify the manner in which the environmental impact of increasing the intermediate storage capacity for nuclear fuel will be assessed.

4.1.8 Helsinki Uusimaa Regional Council

The Helsinki Uusimaa Regional Council considers that the assessment programme provides sufficient conditions for the preparation of the assessment report. The council notes that the project options presented in the programme are in accordance with the current regional plans and the Eastern Uusimaa phase county plan 2050 approved by the Regional Council on 25 August 2020. The project area also has a waterfront plan and a change and extension of the town plan for the nuclear power plant area in Hästholmen. The regional plan is not valid in the area of a general or town plan with legal effect, but it is a guide when drawing them up and changing them.

4.1.9 Municipality of Lapinjärvi

The Municipality of Lapinjärvi considers that it is important to take sufficient account of safety and preparedness aspects for the entire area of impact of the project, regardless of the municipal limits.

4.1.10 The City of Loviisa

The City of Loviisa's City Board is in favour of continuing the use of the nuclear power plant, as it does not see any problems with the safety or production capability of the nuclear power plant. The City considers nuclear power to be an invaluable way of producing carbon dioxide free and domestic electricity for growing needs.

The City notes that the infrastructure requires, and has required, significant investments, e.g. to ensure the safety of the electricity transmission. If the use is discontinued and a new nuclear power plant is built elsewhere, such investments will have been wasted. The City refers to the significant local economic impacts of the plant, such as local employment.

According to the City of Loviisa, Hästholmen is well suited for nuclear power plant operations, and the City has no plans or needs to change the planning of the area in such a way as to call the operation into question or become more difficult.

The City of Loviisa's Building and Environment Board considers it important to investigate and evaluate all activities that could reduce the thermal load at sea in the context of continued operations (VE1). Cooling water has a local impact on the surrounding area, such as the eutrophication of shallow sea bays. The programme has pointed out that water construction work may make it possible to reduce the temperature of cooling water discharged into the sea.

The board considers it important to examine the impact of the current water supply and the water level rationing it includes on Lake Lappominjärvi and its surroundings, as well as in Lappomviken. The domestic water is currently processed from raw water pumped from Lake Lappominjärvi. According to the programme, alternative ways of using water (process, fire, washing, rinsing and domestic water) will be considered.

4.1.11 City of Porvoo

The City of Porvoo considers the assessment programme to have been broadly and comprehensively developed and that the key impacts have been identified. In some places, however, the programme was difficult to understand, which should be taken into account during the reporting phase.

According to the City of Porvoo, the programme does not indicate whether the continued use is projected to increase the thermal load on the seawater and how the effects of any increase in the thermal load are to be assessed. The City of Porvoo also points out that the water impact assessment should take into account the combined effects of various load factors, such as the thermal load, water turbidity due to marine construction and nitrogen emissions from the treatment of evaporation concentrations.

The City of Porvoo proposes that the energy market and security of the supply section of the programme should present the plant's share of Finland's electricity production in a more transparent manner, including a long-term assessment of the electricity production and the share of Loviisa Nuclear Power Plant. In this case, it would be easier to compare the continuation of licences with substitute alternatives. In addition, the method of calculating CO_2 emissions should be clarified, at the latest, during the report phase.

4.1.12 Municipality of Pyhtää (Environmental Services of the City of Kotka)

The Municipality of Pyhtää states that the assessment programme is comprehensive and that it has identified the most significant environmental impacts of the project. However, Pyhtää would like to emphasise Pyhtää and the proximity of key settlements (about 20 km from Loviisa). It is therefore important to identify sensitive sites and examine the main impacts to an adequate regional extent. The presenting of sensitive locations, their distances and impacts by using maps and rings would illustrate the situation and hence also preparedness measures.

4.1.13 Ministry of the Interior, Ministry of Foreign Affairs, Ministry of Finance, Ministry of the Environment, Regional State Administrative Agency for Southern Finland, Finnish Safety and Chemicals Agency Tukes

The above authorities had no statements on the project.

4.2 OTHER STATEMENTS REQUESTED

4.2.1 Greenpeace

Greenpeace stresses the importance of complying with the Espoo and Aarhus agreements and the Environmental Impact Assessment Directive. The organisation notes that the overall economic impact should also be taken into account when examining the various options.

According to the organisation, the assessment procedure should also include a scenario in which the power plant would be shut down early due to a fault in the power plant. Finland's carbon neutrality target by 2035 and the EU's emission reduction target for 2030 should also be included in the review, and the achievement of the targets should be ensured even if the power plants are closed ahead of schedule or the use is not continued after the current licence period.

The organisation proposes that an assessment of the operating reliability of the power plant should be presented in the procedure until the end of any extension to be applied for. The assessment should examine, among other things, the ageing of the reactors and changes in natural conditions and the electricity market. Greenpeace considers the modelling of a serious nuclear accident and the subsequent contingency plan to be a key element of the assessment process.

Further information on the background to the statement was set out in the appendix accompanying the statement.

4.2.2 Fennovoima Oyj

Fennovoima Oyj declares its support for the continuation of the operation of Loviisa Nuclear Power Plant and trusts the authority's ability to assess the safety of the operation of the plant. The company justifies its position by, among other things, reducing greenhouse gases, the security of supply and cost-effectiveness. In addition, the statement mentions the excellent operating history of Loviisa Nuclear Power Plant in terms of safety, usability and reliability.

4.2.3 Natur och Miljö rf

Natur och Miljö rf considers the assessment programme to be, generally, carefully prepared. According to the organisation, the focus of the EIA procedure should be on the safe extension of the life of nuclear power plants, although a review of decommissioning is also essential. For the management of radioactive waste generated in Finland, it is important that option 0+ is also included in the assessment and Finland assumes responsibility for the disposal of these wastes.

Natur och Miljö states that a risk analysis of a nuclear accident is the most important part of the EIA procedure and suggests looking at several different accident scenarios. The organisation also suggests that the citizens' survey mentioned in the programme should cover at least the entire population of southern Finland, as a possible nuclear accident would affect a wider area than just the 20 kilometres proposed in the programme.

According to the organisation, the environmental impacts of fuel management should also be taken into account in the assessment procedure. Section 6.15 (exploitation of natural resources) of the programme should be supplemented by the environmental impact of the production of fuel rods in order to include the effects in the comparison of project options.

If the increase in the capacity of the intermediate storage facility for spent fuel is achieved by placing the fuel more frequently than before, this option shall be presented at the stage of the report with sufficient accuracy to assess the safety. It would also be a good idea to set out in the assessment programme how the thermal load from cooling water will affect the aquatic nature of the area during possible further use. Dredging - presented in the programme - also has side effects that, according to the organisation, can be reduced by choosing the right dredging time.

Natur och Miljö also declares their willingness to participate in stakeholder meetings organised in connection with the project.

4.2.4 Posiva Oy

Posiva Oy states that the various options in the assessment programme have sufficiently prepared for the final disposal of spent nuclear fuel. Posiva Oy has decisions in principle and a construction licence for the final disposal of spent nuclear fuel for a quantity corresponding to 6,500 tonnes of uranium (tU). According to the current service life, the amount of fuel to be finally sourced from the Olkiluoto and Loviisa Nuclear Power Plants is approximately 5,500 tU. If a decision is made to extend the use of the Loviisa 1 and 2 plant units by 20 years, the total amount of spent nuclear fuel would be approximately 6,000 tU. Posiva Oy sees no obstacle to the possible continuation of the use of Loviisa power plant units, as the implementation and safety of their disposal will not be compromised.

4.2.5 STTK ry

STTK ry considers the environmental impact assessment programme to be sufficient. The modifications proposed in the programme are moderately small and do not have a significant impact on the environment of the area. STTK ry welcomes the further use of the power plant based on Finland's high level of nuclear safety and emission reduction targets.

4.2.6 The Central Organisation of Finnish Trade Unions (SAK)

The Central Organisation of Finnish Trade Unions (SAK) says that it strongly supports the continuation of the operation of Loviisa Nuclear Power Plant for 10–20 years, provided that it is safe according to STUK's estimates. SAK justifies its position on the greenhouse gas emissions of nuclear power, the increase in electricity consumption and energy security. In the opinion of the organisation, domestic and affordable electricity supports the competitiveness of Finnish industry.

4.2.7. Finnish Association for Nature Conservation

The Finnish Association for Nature Conservation (FANC) states that the assessment programme has not addressed the impacts of climate change on the operation of the power plant during the planned extension period. Possible impacts include an accelerated sea level rise, increased flooding, rising sea temperatures and mass deposits of new species, as well as increasing sediment runoff due to increasing rainfall, for example. The programme should assess the interactions between climate change and the impacts of the power plant on the water and its organisms (e.g. the presence of invasive alien species).

SLL considers that the environmental impact assessment should be based on the anticipated conditions close to the end of the planned extension period. The programme should assess changes in circumstances and the resulting effects and risks over a period of 20-50 years by using the precautionary principle.

4.2.8 VTT Technical Research Centre of Finland

According to VTT Technical Research Centre of Finland (VTT), the assessment programme is sufficient from the point of view of the EIA Act. VTT considers it a good thing to investigate the continued operation of Loviisa Nuclear Power Plant in terms of national and international climate objectives.

VTT says in its statement that Fortum's EIA programme includes an environmental impact assessment of radioactive waste from VTT, and VTT considers that the waste has been duly taken into account in the programme. VTT states that in March 2020 they signed an agreement with Fortum to dismantle the FiR 1 research reactor, as well as a research reactor and a decommissioned research laboratory (Otakaari 3) for radioactive waste management services.

VTT's radioactive waste is generated by these demolition works. Fortum's EMI programme has also referred to the environmental impact assessment of the decommissioning of the FiR 1 research reactor previously carried out in 2013-2015.

VTT understands that radioactive waste generated elsewhere in Finland (up to 2,000 m³), which may be disposed of at Loviisa Nuclear Power Plant, also includes other radioactive waste that requires disposal from VTT, i.e. at least waste from the operation of VTT Centre for Nuclear Safety. The amount of these radioactive wastes has yet to be specified and has not been the subject of contractual negotiations. VTT considers that the maximum amount proposed by Fortum is sufficient preparedness.

VTT also considers it excellent that the VLJ repository should also be prepared to dispose of radioactive waste from other parts of Finland. According to VTT, this is very positive from the point of view of the national waste management of radioactive waste.

4.2.9 Fingrid Oyj, Teollisuuden Voima Oyj

Fingrid Oyj and Teollisuuden Voima Oyj have not provided statements on the project.

4.3 STATEMENTS OF THE INTERNATIONAL CONSULTATION

4.3.1 Austria

Austria's Ministry of Climate, Environment, Energy, Mobility, Innovation and Technology has announced Austria's participation in the environmental impact assessment procedure. According to the Ministry, the possibility of significant environmental impacts on Austria cannot be excluded in the event of a serious accident in the first place. It is hoped that Finland will later send Austria an assessment report, as well as information on public consultations and participation in the procedure.

The statement was accompanied by a statement commissioned by experts from the Austrian Environment Agency. The statement adopts a position on the content of the environmental report in several sectors. It states that the assessment of project options should take into account scenarios for future electricity needs, energy efficiency, energy saving and other alternatives to electricity generation.

The EIA report should include timetables and options for nuclear waste management arrangements in the event that the capacity necessary to dispose of low- and medium-level waste and spent fuel generated during continued use is not available. The report should also comment on the functionality of the KBS-3 method with regard to copper corrosion.

The statement addresses the aspects of the long-term use and ageing of the VVER 440 reactor type and highlights the studies carried out by several different parties in this regard.

According to the statement, the EIA report shall include a comprehensive description of the current level of science and technology, as well as explanations of all cases in which derogations are made. The report should also include all measures to improve service life and prevent a serious reactor accident. The fragility of the pressure medium should also be treated.

The analysis of an accident situation should be updated to the updated probability-based risk analysis, as the source term presented in the programme is too low in this respect. The source term is also considered to be too low for the analysis of the potential impact on Austria. The EIA statement should explain how the safety issues related to the retention of molten core pressure have been resolved. The opinion states that situations related to earthquakes, floods and extreme weather phenomena (including safety margins, extreme consequences and planned measures to prevent these) should be presented in the EIA report. In addition, the review of accident situations should consider a situation in which a nuclear facility is attacked by a third party.

In its opinion, the Anti Atom Beauftragter des Landes Oberösterreich (state office) puts forward 12 arguments to which it proposes to waive the user life extensions of Loviisa Nuclear Power Plant units. In several of these parts, it notes that the information provided is incomplete and better and more complete information is necessary during the EIA report phase. The number one argument is that extending the use of the nuclear power plant raises the risks of nuclear energy in Europe, as the majority of European nuclear power plants are technically obsolete in terms of nuclear safety. An example of ageing phenomena has been the radiation framing of the reactor pressure container at VVER power plants, which also applies to the pressure containers of Loviisa Nuclear Power Plant. The statement states that the recovery heating of Loviisa 1 occurred in 1996 and that further processing by the PMI requires further information on the management of the life of the reactor pressure containers at the nuclear power plant. More concrete and complete information on decommissioning measures is also required for the decommissioning of the entire plant during the report phase.

4.3.2 Latvia

The Latvian Environmental Authority declares that, though Latvia will not participate in the environmental impact assessment procedure, it hopes to be informed of the results of the assessment procedure.

4.3.3 Lithuania

The Lithuanian Ministry of Environment has announced Lithuania's intention to participate in the environmental impact assessment procedure. The Ministry points out that the procedure should focus, in particular, on the implementation and promotion of the management of the ageing nuclear power plant, and the related safety aspects should be dealt with in accordance with the Espoo Agreement.

4.3.4 Norway

The Norwegian Environmental Authority has no objections to the environmental impact assessment programme, but says that it wants to participate in the later stage of the procedure.

4.3.5 Poland

The Polish Environmental Authority declares that it does not intend to participate in the environmental impact assessment, but hopes to be informed of the results of the procedure and, in particular, accident modelling. The Environmental Authority says that it has taken into account protected species and habitats in the Gulf of Finland, as well as Natura 2000 sites, and has assessed radiation exposure in the event of a disturbance.

4.3.6 Sweden

The Swedish Environmental Protection Agency (Naturvårdsverket) has announced Sweden's will to participate in the environmental impact assessment procedure. The agency sought opinions on the assessment programme from authorities, organisations and citizens. Summaries of statements issued by organisations and citizens can be found in section 4.4. Other statements and opinions.

According to the Swedish Radiation and Nuclear Safety Authority (Strålsäkerhetsmyndigheten), a serious accident at the nuclear power plant is highly unlikely, but would affect the radioactivity of Swedish soil, for example. It is therefore important for Sweden to be involved in the assessment process. According to STUK, the assessment programme is well planned. According to their statement, however, the programme could emphasise the increase in the intermediate storage of spent fuel, as it increases the possibility of the release of long-life nuclides (Cs-137). The best available technology should be used to minimise emissions when extending the service life of a power plant. Moreover, according to the statement, the programme could make it clearer that the expert opinions used in the procedure are also based on various studies and measurements.

The Swedish Board of Agriculture (Jordbruksverket) states that the procedure should examine the effects of radioactive substances released in the event of an accident on Swedish agriculture, animal husbandry, fisheries, reindeer husbandry, farming, rural areas and forest management.

The Swedish Agency for Marine and Water Management (Havs och Vattenmyndigheten) states that the assessment of cross-border environmental impacts highlights accident situations that may have consequences for species and habitats in the Baltic Sea. The statement also states the effects of normal operations on water bodies in relation to the extraction and restoration of cooling water. However, the authority does not consider it necessary to participate in the assessment procedure.

The Swedish Sámi Parliament (Sametinget) highlights the effects of a possible accident on reindeer herding. In the event of an accident, radioactive discharges may accumulate in reindeer which will have to be culled due to excessively high levels of harmful substances, which will then, as a result, cause economic damage. This is what happened as a result of the Chernobyl Nuclear Power Plant accident. The programme should examine the impact of an accident on the reindeer herding area, measures to mitigate any damage and who will be responsible for damages.

The following parties replied to the request for statements, but had no objections to the assessment programme: Totalförsvarets forskningsintitut, Sveriges meteorologiska och hydrologiska institut (SMHI), Myndigheten för samhällsskydd och beredskap, Länsstyrelsen i Uppsala, Länsstyrelsen i Stockholm.

4.3.7 Germany

Germany's statement is given primarily by the state of Mecklenburg-West Pomerania. The state of Mecklenburg-West Pomerania states that it is in favour of decommissioning the power plant on the basis of nuclear accidents. According to the state, the impact assessment of the continuation of the operation of the power plant (VE1) should take into account the fragility of the pressure containers.

A statement was also issued by the state of Rheinland-Pfalz, which states in its opinion that EU countries have the right to choose their own energy sources. Finland has chosen the path towards further construction of nuclear energy. The state prefers energy saving and the use of renewable energy resources. Rhineland-Pfalz adopts a negative view of Loviisa's further use, which means that it sees decommissioning as the best option in the EIA. It emphasises that, due to high-risk technology, an accident in Loviisa could affect a state 1,800 kilometres away within a matter of hours.

4.3.8 Denmark

The Danish Emergency Management Agency has declared its wish to participate in the environmental impact assessment procedure. According to the Emergency Management Agency, a more realistic source term should be used when calculating the health and environmental impact of a major accident as set out in the assessment programme, whilst a mixture of different isotopes should be considered. According to the Agency, the values now used (100 TBq Cs-137-nuklids) are an acceptable way to reduce the computational burden. However, they do not correspond to the real effects of an accident, as different isotopes, for example, affect different tissue types. In addition, the agency expects the responsible party to the project to supplement the chapter on the prevention and mitigation of harmful effects, including with regard to the release of radioactive substances.

4.3.9 Russia

The Ministry of Natural Resources and the Environment of the Russian Federation declares Russia's interest in international consultations on the EIA procedure concerning Loviisa Nuclear Power Plant, even though it is not a party to the Espoo Agreement.

4.3.10 Estonia

The Estonian Ministry of Environment has announced Estonia's participation in the environmental impact assessment procedure. The Ministry of Environment states that it has organised a public consultation on the matter, but there were no comments on the assessment programme.

The statement of the Ministry of Environment was accompanied by the statement of the Environmental Board. The statement concludes that the options set out in the programme do not entail any greater environmental impact or risk than at present. The Environmental Board supports the continued operation of the power plant and states that it is a more useful solution for both Finland and Estonia. The statement deals with well-functioning cooperation with STUK and states the assessment of exceptional and accident situations in accordance with the programme.

4.4 OTHER STATEMENTS AND OPINIONS

4.4.1 Common Earth, Friends of the Earth Austria, Friends of the Earth Bulgaria, Friends of the Earth (FoE) Finland, South Bohemian Mothers, Verein Lebensraum Waldviertel, Wiener Plattform Atomkraftfrei

The abovementioned organisations submitted the same opinion to the Ministry. According to their statements, the environmental report should present an option based on renewable energy and a long-term forecast of Finland's energy needs. According to the organisations, the report needs to specify the risk assessments of serious nuclear accidents, use a larger source term and look at the wider scope. The statements refer to the flexRISK research project. The organisations point out that the report should also address the impact of the risks posed by the ageing of the facility, such as terrorism and climate change. In addition, the associations state that the assessment programme should take a position on the method of disposal of nuclear fuel used for copper corrosion research.

4.4.2 Folkkampanjen mot Kärnkraft & Kärnvapen

The Swedish organisation Folkkampanjen mot Kärnkraft & Kärnvapen supports the decommissioning of the power plant without the possibility of receiving waste from other parts of Finland (VE0). The organisation justifies its position on the safety risks arising from the ageing of the nuclear power plant, the proliferation and affordability of renewable energy sources and the need to protect the Baltic Sea from pollution and radioactive discharges.

4.4.3 Loviisan Seudun Vihreät ry

Loviisan Seudun Vihreät ry suggests that the assessment report should include a table comparing CO2 emissions from different forms of electricity generation sources, taking into account the entire life cycle, including fuel management. The procedure should also consider the option of extending the operating licences of Loviisa Nuclear Power Plant, but not the importing of radioactive waste from other parts of Finland into the plant area. The procedure should assess the impact of the continuation of use on the ecosystem of the Loviisa sea area, such as fisheries, plankton and demersal animals.

4.4.4 Miljöorganisationernas kärnavfallsgranskning

According to the Miljöorganisationernas kärnavfallsgranskning (MKG) organisation, extending the use of the nuclear power plant means a significant risk for Sweden, as the risks of an accident will increase as the plant ages. MKG refers to the flexRISK study, which suggests that the source term and scope used in the accident modelling are too small. The organisation states that the service life of the plant should not be extended if there is no guarantee that the nuclear waste processing will be sustained. MKG refers to the KBS-3 method and copper corrosion research.

4.4.5 Miljövänner för kärnkraft

Miljövänner för kärnkraft considers the assessment programme to be comprehensive and relies on the safety culture of the Finnish nuclear industry. The organisation says that it expects the operating licences of the plants to be extended, citing, among other things, greenhouse gas free use. The opinion highlights the global experience that the lifespans of pressure and light water reactors are longer than initial estimates. The statement states that, according to the organisation, Sweden does not need to participate in the assessment.

4.4.6 Naiset Atomivoimaa Vastaan and Naiset Rauhan Puolesta

According to the Naiset Atomivoimaa Vastaan and Naiset Rauhan Puolesta (Women against Atomic Power and Women for Peace movements), the operating licences for Loviisa Nuclear Power Plant should not be extended. The movements justify their position on the risks posed by the plant's ageing and climate change, among other things. The movements also call into question the safety of the disposal methods.

According to their statement, the assessment programme should present a risk report comparing the measures taken and plans to extend the service life with the safety requirements for new reactors. The movements stress that the risk of a nuclear accident should be dealt with in a transparent manner, and the assessment should also include an examination of the most serious accident possible.

The movements would like to know how the programme takes into account the principle of the best available technology in the EU and on which energy consumption forecasts the need to extend the life of the power plant will be established. The statement also highlights the potential impacts of climate change on activities and the impact on the environmental impacts of fuel production.

4.4.7 Ecomodernist Society of Finland (ESF)

The Ecomodernist Society of Finland advocates for the continuation of the operation of Loviisa Nuclear Power Plant for 10 or 20 years, provided that the operation is safe. According to the organisation, Loviisa Nuclear Power Plant will play an important role both in Finland's energy supply and in reducing greenhouse gas emissions between 2030 and 2050. As additional reasons, the organisation highlights the growing emission-free electricity demand of industry, the electrification of transport and the elimination of other stable and flexible production capacity.

4.4.8 Technology Industries of Finland

According to Technology Industries of Finland, the assessment has been properly prepared and meets the requirements of the act. The organisation declares itself in favour of continuing the operation of the power plant, as Finland will need more carbon dioxide neutral electricity over the next few decades. The organisation states that the operating factors of the Loviisa plant units are high, and the units are in a state of new condition as a result of modernisation work and the renewal of automation systems.

4.4.9 Vesiluonnon puolesta ry

The Vesiluonnon puolesta ry association takes a stand in favour of investigating the environmental impact of radioactive substances and environmental toxins. The procedure should assess the impact of the transportation and production of nuclear fuel with sufficient precision, and the organisation also considers it important, among other things, to protect the life of the region, e.g. in relation to the extraction of cooling water.

4.4.10 Opinions of private individuals

Opinion 1 supports the extension of the operating licences for Loviisa Nuclear Power Plant, as this would contribute to achieving Finland's climate objectives in a cost-effective manner.

Opinion 2 deals with the eutrophication of Lappomviken and Lappomträsket, the fall in water levels and the disappearance of the bird population in the area. According to an individual, Fortum has failed to comply with the obligations under the water permit regarding the Lappomträsket landing stream to Lappomviken and Sundet's outfall. They suggest taking the power plant's domestic water from Valko, Loviisa, and stress the need to improve Lappomviken's condition as soon as possible.

Opinion 3 was signed by two citizens. The statement takes a position on the water observation programme under the responsibility of the ELY Centre, which, in the opinion of the statement- givers, is too limited. The statement states that the condensate of the power plant will also affect the wider areas of Hästholmsfjärden and Kristianslandet. The statement refers to a decision of the Supreme Administrative Court (508/2017) ordering Fortum to pay compensation for the difficulty of recreational use to owners of beach properties in the area.

In an international consultation under the Espoo Agreement, 11 German and Belgian citizens signed a statement with identical content (Opinions 1 to 9). The statement referred to nuclear accidents that have occurred and noted that the risks would increase as the nuclear power plant ages. According to the statement, nuclear waste cannot be stored safely for millions of years. Nuclear power is not climate-friendly, taking into account the entire lifecycle of production. The statement advocates investing in renewable energy sources.

Statement 10 states that Loviisa Nuclear Power Plant should be shut down as soon as possible. The VLJ repository and other storage facilities belonging to the plant complex should be moved off the coast. The statement also questions the safety of the final disposal of spent fuel.

Statement 11 opposes extending the life of the nuclear power plant. The writer refers to the increasing risks of an ageing nuclear power plant, the flexRISK study and uncertainties related to the method of disposal of spent fuel.

4.5 REMARKS MADE AT A PUBLIC EVENT

The Ministry of Economic Affairs and Employment organised a public event on the assessment programme in Loviisa on 3 September 2020. Fortum was responsible for the practical arrangements for the event. Six people attended the public event on site, and about 50 people followed the event online. The event discussed, among other things, possible investment needs, the reception of radioactive waste generated elsewhere in Finland and the fate of the plant building after decommissioning. In addition, the public were concerned about the impact of various further options on the value of nearby properties.

5. Statement of liaison authority

The statement of the Ministry of Economic Affairs and Employment is based on the requirements of the EIA Act and Decree (Law on the environmental impact assessment procedure section 16, section 18, section 3 Government Decree on the environmental impact assessment procedure) and on the statements and opinions obtained from the assessment programme.

The Law on the environmental impact assessment procedure section programme drawn up by Fortum Power and Heat Oy covers content requirements in accordance with section 3 of the Law on the environmental impact assessment procedure section. In the adopted statement, the assessment programme is considered to be largely comprehensive. The Ministry considers that the scope and accuracy of the assessment programme is a sufficient plan to assess the environmental impact of the project, provided that the issues set out in this statement are taken into account as the project progresses and at the later stages of the EIA procedure. In addition, other questions, comments and considerations have been raised in the statements and opinions to which the responsible party to the project should pay attention.

The responsible party to the project shall examine the impacts of the project and its options on the basis of the assessment programme and the statement of the liaison authority. In accordance with Article 4(15) of the EIA regulation, the assessment report shall provide an explanation of how the liaison authority's statement on the assessment programme has been taken into account.

5.1 PROJECT DESCRIPTION AND OPTIONS

In accordance with Article 3 of the EIA regulation, the assessment programme provides descriptions of the project, its purpose, the planning phase, location, size, land use needs and the project's connection to other projects. The programme shall contain information on the party responsible for the project, an assessment of the timetable for the design and implementation of the project and the plans and licences required for the implementation.

According to the EIA regulation, the assessment programme must present reasonable options to the project, which are worthy of the project and its specific characteristics. One option must be to not to carry out the project. The definition and review of options are key elements of the EIA procedure, as the aim is to provide information on the impact of alternative solutions to the project and to reduce the adverse environmental impact of the project.

5.1.1 Continuation of use

In project option 1, the power plant use would be extended for a maximum of approximately 20 years. The assessment programme states that the operation would be similar to the activities carried out so far, and there are no plans to increase the thermal power, for example.

However, further use may require some modernisation and construction work. The intermediate storage of spent fuel would either be expanded or its capacity increased. In connection with the cooling water supply structures, water construction work aimed at reducing the temperature of cooling water would possibly be carried out. Some old buildings, such as a reception facility and a sewage plant, may be replaced by new buildings, in addition to which changes may be made to the power plant's operating and wastewater connections.

Option 1 would also provide for decommissioning, including the extension and operation of the VLJ repository until approximately 2090 before closure, as well as preparatory work and use of the installations to be independent, and finally decommissioned.

5.1.2 Zero options

The assessment programme includes two zero options (VE0, VE0+), both of which would decommission Loviisa Nuclear Power Plant after the current operating licences have ended. The options are otherwise the same, but option 0+ would also make it possible to process, intermediately store and dispose of small amounts of radioactive waste generated elsewhere in Finland.

In the EIA programme, decommissioning refers to the dismantling of radioactive systems and equipment of the power plant and the disposal of waste resulting from the dismantling. During its operation, preparations for decommissioning will be made, e.g. by expanding the VLJ repository so that radioactive waste from decommissioning can be disposed of there. In addition, in connection with decommissioning, certain waste management activities and facilities must be independent, among other things. According to the assessment programme, the decommissioning phase of the power plant units would be set between 2030 and 2040. The VLJ repository would continue to be used until about 2065.

A decommissioning licence must be applied for the decommissioning of the power plant. Decommissioning is regulated by the Nuclear Energy Act and Decree and STUK's decrees and guidelines.

5.1.3 Comparison of options

Comparing the options to the project and their environmental impact is a key part of the EIA procedure. The assessment programme states that during the procedure, comparisons will be made between the environmental impact of the project and its non-implementation and the differences between them. The assessment of the significance of the environmental impacts takes into account both the magnitude of the change and the sensitivity of the impact site. Impacts are classified on the basis of their significance as minor, moderate, large and very large. The impacts can be either positive or negative from an environmental point of view.

5.2 IMPACTS AND THEIR INVESTIGATION

The assessment programme describes the current state and development of the likely scope of the project. The assessment programme shall detail the initial areas of the analysis and impact, the scope of which has been assessed on an impact-by-impact basis.

The assessment programme shall include a proposal on the identified and assessable environmental impacts, including transnational environmental impacts and interactions with other projects, as well as a justification for limiting the impacts to be assessed.

According to the programme, the most significant environmental impact of the project in the case of continued use, estimated on the basis of preliminary planning data, is the thermal load of cooling water in the nearby sea area. Similarly, the most significant environmental impacts of preparing for decommissioning have been provisionally identified as the effects of mining related to the expansion of the VLJ repository. Based on a preliminary assessment, the most significant environmental impacts of decommissioning are due to the dismantling of radioactive plant parts and the treatment, transport and disposal of waste.

The studies on environmental impacts, as well as the methodology used and related assumptions, are described in the programme. In addition to utilising previous studies, specific studies will be carried out as part of the assessment, including a study of sedimental harmful substances on the seabed and an assessment of regional economic impacts.

According to the assessment programme, the uncertainties associated with the assessment and their significance are described in the assessment report, which also provides a description of the prevention and mitigation of adverse effects. In the context of the environmental impact assessment, the existing environmental impact monitoring programme will be reviewed and, if necessary, updated.

Next, the Ministry will present some detailed points that the responsible party of the project should take into account in the further work of the project.

5.2.1 Continued operation and management of the ageing of the plant

In project option 1, the power plant use would be extended for a maximum of approximately 20 years. The assessment programme states that the ageing of systems, structures and equipment will be prepared for by design-phase solutions, in-service monitoring and by maintaining the plant's good condition until decommissioning. The assessment programme also mentions the measures taken in recent years to modernise the plant and states that the power plant is in excellent technical and safety condition, which is what is required for the plant to continue its operation after the licence periods in force.

There was a mixed attitude towards continued use in the statements. A large number of Finnish statement providers said that they were in favour of further use of the power plant. The position was justified e.g. by the plant's good operating history, a high-quality safety culture, previous modernisation work, emission reduction targets and employment impacts.

There were objections to continued use in the opinions of the Austrian and German state statements and from NGOs and citizens. In particular, the growing nuclear safety risks, such as the fragility of the pressure testing system, were highlighted due to the ageing of the plant. In addition, according to Greenpeace, a scenario should be included in the assessment procedure in which the power plant would be shut down early due to a fault in the power plant. In its statement, Lithuania also stressed the importance of managing the ageing plant.

According to STUK and the Swedish Radiation and Nuclear Safety Authority, the BAT principle should be applied in the assessment report to reduce emissions, especially if the plant continues to be used. According to Austria's opinion, the EIA report should include a description of the current level of science and technology and a description of all the cases where these are deviated from. The report should also list all the planned actions to promote service life and safety.

The Ministry of Economic Affairs and Employment considers it important that the risk factors related to the possible continuation and decommissioning of use and the effects of the plant's ageing are investigated and that the means of preventing or mitigating the effects are carefully assessed. STUK will assess the safety of continued use or decommissioning later in connection with the processing of the licence application.

The Ministry believes that the report should describe closely the methods by which ageing is monitored and how the consequences of ageing will be reduced. In particular, the method of preventing potential risks of an accident due to ageing and therefore high emissions, such as the ageing of the pressure vehicle, should be described. The report should also address the application of the BAT principle in reducing or preventing emissions.

5.2.2 Cooling water supply, water construction, impacts on water bodies and their lives

According to the assessment programme, the most significant environmental impact of continued use is the thermal load on the local sea area due to the restoration of cooling water. In connection with option 1, possible hydraulic works in front of the cooling water intake structure and in the near-sea area have been described. The aim is to reduce the temperature of the cooling water to be taken and possibly restored. The programme has identified environmental impacts from dredging, mining and the construction of a new embankment structure related to water construction.

The effects related to the taking of cooling water were highlighted in several opinions. The City of Loviisa's Building and Environment Board considers it particularly important that the procedure assesses all measures to reduce the thermal load on the sea. According to the Geological Survey of Finland, the assessment procedure should take into account the effects of warming seawater caused by climate change on the temperature of the water returned to the sea.

STUK requires that the procedure investigates the amounts of artificial radioactive substances in sediments in the dredging area and assesses their possible release in connection with dredging work. Cooling water modelling that takes into account the new embankment structure should take into account the effects of changes in flow fields on the transport of radioactive substances.

The Uusimaa ELY Centre also proposes that the report should specify information on the harmful substance study of the sediment, the impact of waterworks on flow conditions and cooling water modelling.

The City of Porvoo points out that the combined effects of various factors, such as thermal load, water turbidity and nitrogen emissions, should be taken into account when assessing water impacts. The statements of the Ministry of Agriculture and Forestry and the ELY Centre draw attention to the impact on the lives of water bodies. The statement calls for compliance with the precautionary principle and states that activities in spawning and occurrence areas important to fish stocks, for example, should be avoided.

The domestic water of Loviisa Nuclear Power Plant is currently taken from Lake Lappominjärvi. The City of Loviisa's Building and Environment Board and the Uusimaa ELY Centre consider it to be important to investigate the impact of project exchanges on Lake Lappominjärvi, its surroundings and Lappominlahti bay. The area was also highlighted in one of the statements from the citizens on the eutrophication of Lake Lappominjärvi and Lappominlahti bay, the fall in water levels and the disappearance of some bird species.

The opinions also took a position on reducing the adverse effects of dredging by choosing the right time, the extent of the condensing water monitoring area, the protection of life and the assessment of marine ecosystem impacts.

The Ministry considers that the effects of cooling water are the most significant environmental impacts of a nuclear power plant during normal operation. Therefore, when considering the environmental impacts of the thermal load, the available information must be widely exploited. The modelling shall also take into account the impact of climate change on the plant's environmental load. The calculation of the environmental load due to cooling water should be presented conservatively and the results presented in an illustrative manner. The Ministry also notes that the environmental impact assessment of water bodies should not be limited to cooling waters, but should be assessed for the operation of the entire plant.

5.2.3 Exceptional and accident situations

According to the assessment programme, the EIA report includes the modelling of a serious reactor accident, which assumes that 100 TBq Cs-137-nuclides will be released in an accident. This amount corresponds to the limit value for serious accidents under the Nuclear Energy Regulation. The scope of the accident modelling set out in the assessment programme is 1,000 km from the power plant. In addition, the report also intends to cover other exceptional situations, such as fires or transport-related risk situations, as well as conflicting environmental and safety risks.

Several different statement providers drew attention to the accident modelling presented in the assessment programme. Among other things, the source term used in the modelling of the statements of Austria and several NGOs and citizens, as well as the area of impact examined, were considered too small for an environmental impact assessment In connection with the case, NGOs appealed for flexRISK studies.

The opinion of the Danish Emergency Management Agency also suggested that a more realistic source term should be used to assess the health and environmental impact of an accident situation and to address the mix of different isotopes. However, the Emergency Management Agency says it accepts the use of the chosen source term to reduce the computing burden. Natur och Miljö rf suggests that the assessment procedure should examine several accident scenarios.

The Swedish Agricultural Board states that the procedure should examine the effects of radioactive substances released in the event of an accident on Swedish agriculture, animal husbandry, fisheries, reindeer husbandry, farming, rural areas and forest management. In the event of an accident, the Swedish Sámi Parliament emphasises the impact on reindeer herding.

The Ministry of Economic Affairs and Employment states that in Finland (Section 22b of the Nuclear Energy Decree) a high emission limit value of 100 TBq for caesium-137 has been set, and this value has been used as a source term, which describes the accident in the INES 6 category in Finnish environmental impact assessments. However, a number of statements and opinions have suggested the inclusion of a more realistic source term in the reviews to be made. The Ministry considers that it is appropriate for the responsible party of the project to provide a comparison between the source term used and a more realistic emission estimated for the installation under consideration. At the same time, the responsible party of the project should also examine the safety principles of the installation aimed at preventing high emissions in the event of serious accidents.

In addition, the Ministry of Economic Affairs and Employment states that the impact assessment of exceptional and accident situations should not be limited to the protection zone or the emergency preparedness area. In accordance with the EIA Regulation, the EIA report shall present accident situations causing different emissions and describe, by means of illustrative examples, the extent of the affected areas and the impact of emissions on humans and nature.

5.2.4 External threats

The assessment programme states that the risks posed by climate change, such as floods and sea level rise, will be addressed in the assessment report. The Ministry of Agriculture and Forestry, the Uusimaa ELY Centre and the Finnish Association for Nature Conservation draw attention to the lack of discussion of the effects of climate change in the programme.
The Ministry of Agriculture and Forestry points out that consideration of the risks of climate change should be promoted in projects that, due to the nature or long life of the activity, involve specific climate risks. The Ministry states that the risk of flooding should have also been treated as a separate factor in the programme from climate change.

According to the Finnish Union for Nature Conservation, possible effects of climate change may include accelerated sea level rise, rising sea surface temperatures, increasing sediment runoff due to increasing rains, mass deposits of new species and floods. The Union considers that the environmental impact assessment should be based on anticipated conditions close to the end of the extension period.

The Ministry of Economic Affairs and Employment states that the external threats of the project and the risks arising from climate change must be taken into account when assessing the safety of the project. STUK will assess the safety of the project later in connection with the processing of the licence application. However, the Ministry of Economic Affairs and Employment considers that the analysis should assess the phenomena caused by climate change at the plant site and their preparedness.

5.2.5 Impacts on the climate

The assessment programme states that the climate impacts of the project will be examined through greenhouse gas emissions from the operation. The assessment programme will also compare CO2 emissions from different forms of energy production, based on, among other things, life cycle studies of different fuels.

The Uusimaa ELY Centre states that it would be important to describe the climate impacts of the project under its own heading, broken down by construction and decommissioning and long-term impacts. In the case of climate impact assessments, the ELY Centre should specify whether the impacts of the nuclear fuel production chain and spent fuel disposal are included in the review, and it would also be a good idea to relate the direct climate impacts of project options not only to national climate objectives but also to regional targets.

Natur och Miljö, the Finnish Water Nature Association and several EU citizens pointed out in their statements that the environmental impact of the fuel supply should also be taken into account in the assessment procedure.

Loviisan Seudun Vihreät ry proposes that a table should be included in the assessment report comparing CO2 emissions from different forms of electricity generation, taking into account the entire lifecycle.

According to the City of Porvoo, the method of calculating CO2 emissions from the project should be specified in the assessment report. For its part, the Ministry of Agriculture and Forestry emphasises the importance of taking climate change into account, especially in the case of decommissioning.

The Ministry considers it appropriate for the project manager to examine the climate impacts through greenhouse gas emissions from operations and to compare different forms of energy production, taking into account the life cycle of different fuels.

5.2.6 Energy markets

According to the assessment programme, the impact on the electricity market will be examined, taking into account the different timetables of the options. However, the programme states that, in the case of decommissioning, it is difficult to assess the form and location of the replacement electricity.

The statements commented on Finland's forecasts for electricity production and consumption. According to the views of the Uusimaa ELY Centre and the City of Porvoo, the share of the power plant in Finland's electricity production should be presented in a more transparent manner, including a long-term forecast of the development of the power plant's share and the Finnish electricity market. According to the City, this would make it easier to compare different forms of energy production. According to Austria, the procedure should deal with different scenarios of future electricity needs and different options to electricity generation.

Greenpeace also points out that the overall economic impact of the project should be examined in the procedure.

The Ministry considers that it is appropriate to examine the effects on the electricity market, taking into account the timing of the different options. The results and the starting points of the report must be clearly and transparently expressed. The Ministry also notes that the responsible party for the project is the company producing and selling electricity. It is up to the state to carry out nationwide reviews of energy supply.

In addition, the Ministry notes that the Government, under the leadership of the Ministry of Economic Affairs and Employment, is currently preparing a new national climate and energy strategy with the aim of carbon neutrality in Finland in 2035, in accordance with Prime Minister Sanna Marin's Government Programme.

5.2.7 Impact of continued use on nuclear waste management

The continued operation of the power plant will increase the accumulated total amount of low- and medium-level waste and spent nuclear fuel. The programme estimates that an extension of approximately 20 years would produce approximately 600 m³ of low-activity and 2,400 m³ of additional medium-level waste packed.

However, the methods of nuclear waste management would, as a rule, remain the same, and the existing capacity of the VLJ repository is also estimated to be sufficient for the disposal of nuclear waste resulting from continued use. However, according to the GTK, the extent of the extraction in the case of continued use is unclear and the assessment programme does not sufficiently set out the requirements, in particular the increase in medium-level waste. For excavating additional space in the VLJ repository.

According to the preliminary estimate, the most significant change caused by continued use related to nuclear waste management would be the intermediate storage of spent nuclear fuel at Loviisa Nuclear Power Plant. The annual accumulation of spent fuel is expected to be 24 tonnes of uranium (UO_2). Extending use by approximately 20 years would increase the amount of spent nuclear fuel by just under 500 tonnes of uranium.

According to the programme, the increase in intermediate storage capacity for spent nuclear fuel would be achieved either by expanding the intermediate stockpile or by placing nuclear fuel in intermediate storage tanks more frequently than at present. The cooling need for spent nuclear fuel in the intermediate storage facility is not expected to increase significantly, despite the increasing amount of fuel, as the fuel thermal output is constantly decreasing during the intermediate storage. However, it is possible to increase the cooling capacity if necessary.

The Uusimaa ELY Centre states that it is important to describe in the assessment report which option will be used to assess the environmental impact of the increase in intermediate storage capacity of spent nuclear fuel. According to the Swedish Radiation Authority, the EIA procedure should emphasise the increase in the intermediate storage of spent fuel, as this increases the possibility of releasing long-life nuclides. Natur och Miljö rf suggests that if the intermediate storage of spent fuel is carried out by placing fuel in storage basins more frequently, the alternative must be described in the assessment report with sufficient accuracy to ensure safety.

At the end of the intermediate storage, the spent nuclear fuel is to be finally deposited at Posiva Oy's disposal facility in Olkiluoto, Eurajoki. STUK's statement points out that more fuel used in connection with the possible continuation of use would be generated than previously taken into account in the licence procedures for the Posiva disposal project. However, Posiva Oy states in its own statement that the decision-in-principle and construction licence granted for the disposal project enable the final disposal of fuel, taking into account the aforementioned fuel increase.

The safety of the final disposal of spent nuclear fuel was called into question in the Austrian statement and in a number of statements by organisations and citizens. In particular, studies on the KBS-3 method on the premature corrosion of copper capsules were highlighted, which Austria said should be commented on in the assessment report. Greenpeace also argued that nuclear waste management should generally be dealt with more comprehensively in the procedure, in particular as regards disposal.

The Ministry of Economic Affairs and Employment states that despite the increase in the amount of nuclear waste caused by continued use, the methods of nuclear waste management will, as a rule, remain the same and it will be possible to increase the necessary capacity. The Ministry periodically assesses the effects of the increase in low- and medium-level nuclear waste and spent fuel as part of the Loviisa nuclear waste management package. If necessary, the increase in the amount of spent nuclear fuel and its impact on Posiva Oy's operations must be taken into account.

STUK assesses the safety of nuclear waste management in connection with the processing of possible operating licence applications for Loviisa Nuclear Power Plant. In addition, STUK assesses the safety of the final disposal of spent nuclear fuel in connection with the processing of Posiva's operating licence application. In the Ministry's view, it is sufficient at this stage for Fortum to ensure that the investigation related to corrosion of the copper capsule is carried out, e.g. by Posiva Oy as part of the preparations for the operating licence phase of the encapsulation and disposal. In addition, the report shall specify on the basis of which option the environmental impact of the increase in intermediate storage capacity of spent nuclear fuel is assessed.

5.2.8 Decommissioning and independence of spent fuel intermediate storage facility, liquid waste storage facility, solidification plant and VLJ repository

After the operation phase of Loviisa Nuclear Power Plant, the decommissioning of nuclear power plant units will be carried out. The decommissioning strategy of the nuclear power plant has been selected as an immediate dismantling. However, the dismantling will be preceded by a preparatory phase lasting a few years. The assessment programme provides two alternative times for decommissioning. In option 1, the decommissioning would take place between 2050 and 2060. In options 0 and 0+ decommissioning would take place after an already valid operating licence in 2030–2040.

Loviisa Nuclear Power Plant has a decommissioning plan in accordance with the decommissioning strategy. The decommissioning plan is currently based on the nuclear power plant's 50-year service life and decommissioning after the current operating licence in 2030-2040. The decommissioning plan sets out all phases of decommissioning and their up-to-date plans. The decommissioning plan will be evaluated at regular intervals, and the plan will develop based on the operating experience of the nuclear power plant, regulatory feedback and the monitoring of international projects towards the final plan before the decommissioning is carried out.

Decommissioning is carried out in two phases in time. In the first phase, the intermediate storage of spent nuclear fuel from nuclear power plant units, the intermediate storage of liquid waste, the solidification plant and the VLJ repository will be independent, and the nuclear power plant units will be dismantled. At the end of the intermediate storage of nuclear fuel used in the second phase, i.e. in the 2060s at the earliest, the remaining plants will be dismantled and the VLJ repository will be closed.

The decommissioning and dismantling of Loviisa Nuclear Power Plant produces significant amounts of low- and intermediate-level waste, but the accumulation of spent fuel will end at the end of the operating phase. Decommissioning involves a significant amount of waste characterisation, sorting, packaging, transport and disposal. According to the programme, the amount of decommissioning waste to be disposed of is approximately 25,000 m³.

The assessment programme has provisionally identified, as the most significant environmental impacts possible, radiation exposure of personnel in the dismantling of radioactive plant parts, waste treatment, transport and disposal. In addition, impacts may also arise from process waters that are treated and discharged cleaned into the sea. Other environmental impacts related to the end of operations have also been provisionally identified.

In the Ministry's view, the decommissioning part of the programme is sufficient. The Ministry shall periodically evaluate the updated decommissioning plan for Loviisa Nuclear Power Plant. The decommissioning plan shall also discuss the radiation protection planning of personnel. In its previous assessment, the Ministry has drawn attention to the coverage of the plan with regard to the use of independent plants and, initially, their decommissioning. The final decommissioning plan for Loviisa Nuclear Power Plant will be approved by STUK during the decommissioning licence phase.

5.2.9 Expanding, operating and closing the VLJ repository

According to the programme, the VLJ repository will be expanded already during the operation of Loviisa Nuclear Power Plant for the disposal of decommissioning waste. If Loviisa Nuclear Power Plant enters the decommissioning phase after the expiry of the operating licence in force (VE0 and VE0+), it will be expanded as early as the late 2020s and otherwise (VE1) in the late 2040s.

Disposal facilities for decommissioning waste are designed in connection with existing waste disposal facilities during operation, so that the facilities form a coherent and functional whole. The disposal facilities are located underground at a depth of about 110 metres from sea level.

The excavation and temporary storage of the quarry related to the expansion of the VLJ repository have been identified in the programme as the most significant environmental impact of preparing for decommissioning. According to the programme, the expansion requirement arising from the disposal of decommissioning waste is approximately 57,000 m³.

In its opinion, the Geological Survey of Finland (GTK) states that the need to expand the VLJ repository is significant. GTK also notes that the assessment should examine the need to update the Hästholmen rock model, especially from the point of view of water-conducting structures. The design of the extension must be based on up-to-date structural and hydrogeological data. The need to update environmental impact monitoring programmes must also be specified in terms of the impact of the various options. Global warming, changes in precipitation and the shortening winter season impact, among other things, the monitoring of rock groundwater.

The Uusimaa ELY Centre also considers it important that the report presents a model of soil, bedrock and groundwater conditions based on the latest research results, as well as an assessment of the leakage water accumulated in the rock spaces. The ELY Centre also proposes that the assessment report should specify the utilisation of the quarry resulting from the expansion of the VLJ repository.

According to the programme, the use of the repository shall continue until either the 2060s (VE0, VE0+) or about 2090 (VE1). At the end of the operation, the repository will be closed by filling in the spaces containing the barriers and the driving tunnel, after which the area will remain under the supervision of the authorities.

According to the programme, long-term safety after the closure of the VLJ repository will be assessed as part of the environmental impact assessment. In 2018, the responsible party of the project prepared a safety basis for the disposal of radioactive waste generated during the operation and decommissioning of Loviisa Nuclear Power Plant. The safety criterion demonstrates compliance with the long-term safety requirements for disposal. According to the programme, the assessment report will present the key results of the safety reasoning approved by STUK in 2019 and assess separately, among other things, the impact of extending the life of the power plant on long-term safety.

The Ministry of Economic Affairs and Employment considers it important that the project manager assesses the timeliness of models describing soil, bedrock and groundwater conditions, the amount of leakage water accumulated in rock spaces and the need to update the monitoring programme. The utilisation of the quarry resulting from the expansion of the VLJ repository should also be specified in the report. The expansion of the VLJ repository is significant compared to the existing scope. The lifespan of the VLJ repository will be extended beyond the current operating licence in the options presented. A longer service life requires applying for a new operating licence for the repository. The valid operating licence for the VLJ repository extends until 2055.

In the Ministry's view, it is a good idea to make clear in the report the future licence procedure for the VLJ repository, taking into account the need to expand the repository and the total amount of radioactive waste to be disposed of with a licence. If possible, the closure of the repository must also be taken into account in the length of the operating licence, as, according to the current Nuclear Energy Act, disposal facilities will be closed under the operating licence. In connection with the operating licence procedure, STUK shall assess the long-term safety of the VLJ repository.

5.3 NUCLEAR WASTE MANAGEMENT COOPERATION

Options 1 and 0+ include the possibility to receive, process, intermediately store and dispose of small amounts of radioactive waste generated elsewhere in Finland. Waste generated elsewhere typically comes from industry, universities, research institutes and hospitals. The programme has estimated that the amount of waste generated elsewhere in Finland at Loviisa Nuclear Power Plant will not exceed 2,000 m³, which is a fraction of the total amount of nuclear waste to be disposed of. VTT considers the amount of waste from other parts of Finland presented in the assessment programme to be sufficiently prepared for.

Waste from the operation and decommissioning of VTT's FiR 1 research reactor and Otakaari 3 research laboratory will also be located at the Loviisa power plant. Fortum and VTT have signed an agreement on the dismantling of the research reactor and the waste management services of the research reactor and the decommissioning research laboratory. In addition, one option for decommissioning the research reactor is to store spent and unused fuel at the Loviisa power plant. The import of VTT's waste to the Loviisa power plant area requires a licence in accordance with the Nuclear Energy Act.

The statements are largely positive about receiving waste generated elsewhere in Finland at Loviisa Nuclear Power Plant. VTT and Natur och Miljö rf state that the reception of such waste in Loviisa is important for Finland's national management of radioactive waste. VTT and Natur och Miljö rf state that the reception of such waste in Loviisa is important for Finland's national management of radioactive waste. Loviisan Seudun Vihreät argued that an alternative should be included in the procedure, in which the power plant would continue to be used, but that waste generated elsewhere in Finland would not be imported into the plant area.

According to STUK, the estimated amount of activity of waste from other parts of Finland, the composition of nuclides and the physical and chemical state of radioactive substances should also be reported in the assessment report.

In the view of the Ministry of Economic Affairs and Employment, there must be a treatment and disposal route for all radioactive waste that has been born in Finland. The treatment and disposal of waste generated elsewhere in Finland in the Loviisa Nuclear Power Plant area would significantly complement the national waste management of radioactive materials. The Ministry sees that it is possible for the responsible party for the project to refine the information on the properties of waste highlighted by STUK in the assessment report only in a fairly general way. STUK assesses the safety of the management of radioactive waste generated elsewhere in Finland as part of Loviisa Nuclear Power Plant's waste management package in connection with the licence procedures for Loviisa Nuclear Power Plant and the VLJ repository.

5.4 COMPETENCE OF THE RESPONSIBLE PARTY OF THE PROJECT AND THE LIAISON AUTHORITY

The assessment shall contain information on the competence of the authors of the assessment programme. The Ministry considers that the responsible party for the project has sufficient expertise at its disposal to draw up an environmental impact assessment programme.

The Ministry of Economic Affairs and Employment, which acts as the liaison authority, has ensured that its own personnel involved in examining the environmental impact assessment programme and drafting the liaison authority's opinion has sufficient expertise necessary for the quality and scope of the project under assessment and the complexity of the task.

5.5 PLAN FOR ORGANISING THE ASSESSMENT PROCEDURE AND RELATED PARTICIPATION

The assessment programme shall include a plan for the organisation of the assessment procedure and related participation and interaction. The programme describes public events organised in connection with the EIA programme and later in connection with the EIA report. A monitoring group of different stakeholders will be set up for the assessment procedure. In addition, a survey will be organised for nearby residents as well as small group events for different target groups during the reporting phase.

The Uusimaa ELY Centre and Greenpeace consider it important that the current pandemic situation be taken into account in the participation arrangements. Natur och Miljö rf proposes that the citizens' survey mentioned in the programme should cover the entire population of Finland, or at least southern Finland, as a possible nuclear accident would affect a wider distance than the 20 kilometres proposed in the programme.

The Ministry of Employment and the Economy states that upon completion of the EIA report, the Ministry will announce it and make it available for inspection, as well as request the opinions of the authorities and any other parties. A public event will be organised on the EIA report, in connection with which sufficient opportunities will be arranged for everyone to participate in the event, taking into account the circumstances. Ministry of Economic Affairs and Employment The reasoned conclusion of the EIA report as a liaison authority shall be communicated to the municipalities and authorities concerned.

5.6 TIMETABLE FOR THE EIA PROCEDURE

The assessment programme includes the project and the preliminary timetable for the EIA procedure. According to the assessment presented in the programme, the party responsible for the project will submit the assessment report to the liaison authority in August 2021. The period of viewing of the assessment report will be in September and October 2021.

The reasoned conclusion of the liaison authority would then be adopted in December 2021.

6. Communication of the liaison authority's statement

The liaison authority shall forward its statement and other statements and opinions to the project manager. At the same time, the statement of the liaison authority shall be communicated to the authorities concerned and published on the liaison authority's website.

Minister of Economic Affairs
Mika Lintilä

Senior Specialist
Jaakko Louvanto

Distribution Fortum Power and Heat Oy
Information Ministry of Economic
Affairs and Employment
Relevant authorities
Other statement providers

APPENDIX 3

Consideration of the coordinating authority's statement when drawing up the assessment report

The Ministry of Economic Affairs and Employment, acting as the coordinating (liaison) authority, gave its statement on the project's EIA Programme on 26 November 2020. According to the statement, the EIA Programme drawn up by Fortum Power and Heat Oy covers the content requirements pursuant to section 3 of the EIA Decree. The coordinating authority considered that the scope and accuracy of the assessment programme constituted a sufficient plan for assessing the environmental impact of the project, provided that the issues set out in the coordinating authority's statement were taken into account as the project progressed and at the later stages of the EIA procedure. In addition, other questions, comments and considerations were raised in the statements and opinions to which the project owner should pay attention. In accordance with section 4, subsection 15 of the EIA Decree, the assessment report must provide an explanation of how the coordinating authority's statement on the assessment programme has been taken into account.

The following table summarises the matters to which attention should be paid, according to the coordinating authority's statement, during the impact assessment work, or which should be supplemented when drawing up the assessment report. The information provided in the column on the right describes how the statements have been accounted for in the EIA Report.

Main points given in the statement by the coordinating authority	Consideration in the EIA Report
5.1 Project description and options	
According to the EIA Decree, the assessment programme must present reasonable options to the project, which are credible in terms of the project and its specific characteristics. One option must be not to carry out the project. The definition and review of options are key elements of the EIA procedure, as the aim is to provide information on the impact of alternative solutions to the project and to reduce its adverse environmental impact.	Nothing to consider in terms of what is presented in the programme.
5.1.1 Continuation of use	
In its statement, the coordinating authority describes the project option of extended operation (VE1), in which use would be extended for a maximum of 20 years. The extended use may require some modernisation and construction work. The intermediate storage for spent fuel would either be expanded, or its capacity increased. In connection with the cooling water supply structures, water construction work aimed at reducing the temperature of cooling water might be carried out. Some old buildings such as a reception facility and a wastewater treatment plant may be replaced by new buildings, in addition to which changes may be made to the power plant's operating and wastewater connections. Option VE1 would also provide for decommissioning,	Based on the techno-economic investigations, the water engineering projects are nevertheless no longer being planned, which is why they are not reviewed in the EIA Report.
5.1.2 Zero options	
The coordinating authority describes two zero options (VE0, VE0+) in its statement. A decommissioning licence must be applied for in terms of the decommissioning of the power plant. Decommissioning is regulated by the Nuclear Energy Act and Nuclear Energy Decree and STUK's regulations and guidelines. The coordinating authority's statement did not mention matters that would require separate consideration in the environmental impact assessment.	Nothing to consider in terms of what is presented in the programme.
5.1.3 Comparison of options	
The coordinating authority's statement did not mention matters that would require separate consideration in the environmental impact assessment.	Nothing to consider in terms of what is presented in the programme.

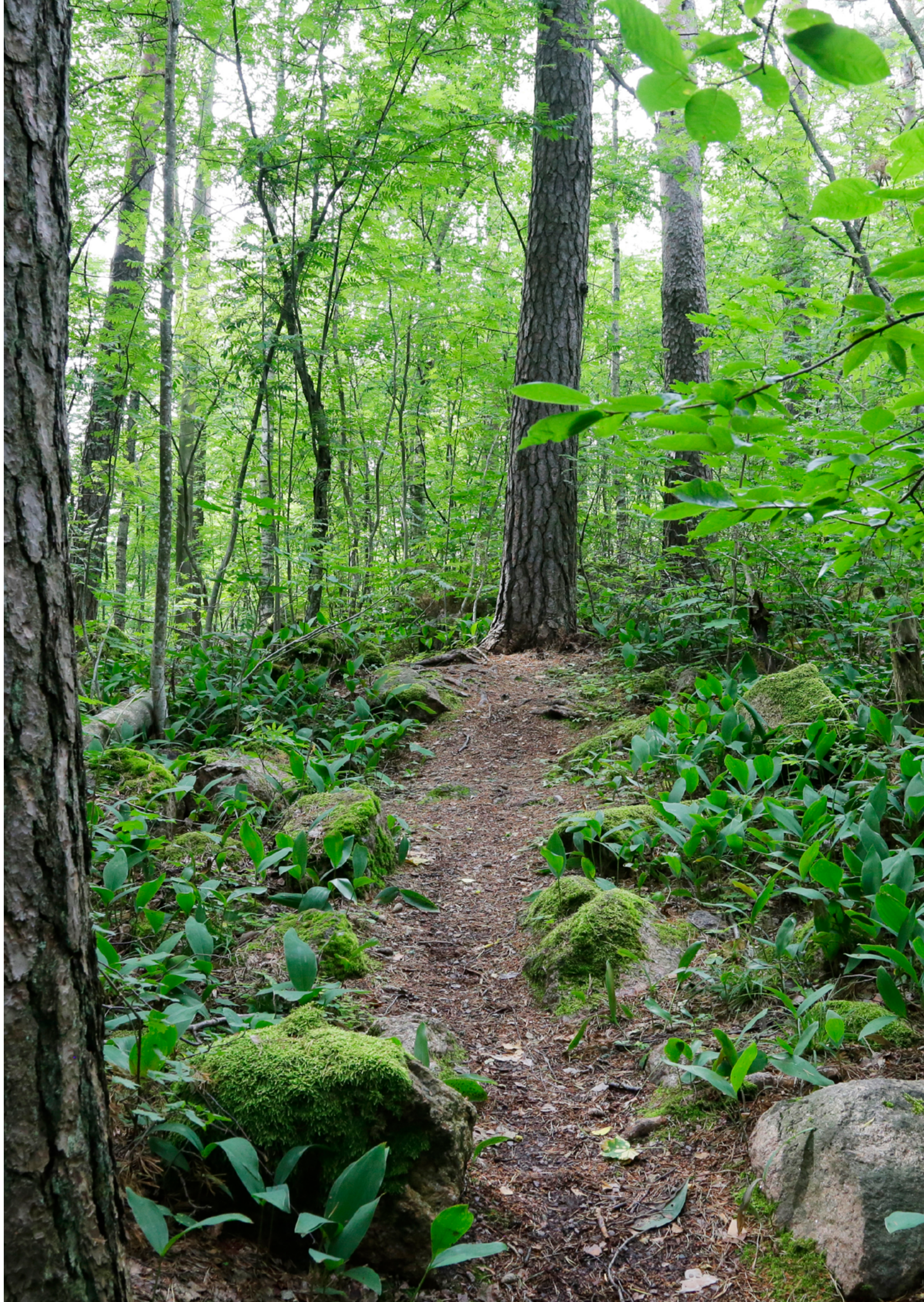
Main points given in the statement by the coordinating authority	Consideration in the EIA Report
5.2 Impacts and their investigation	
5.2.1 Continued operation and management of the ageing of the plant	
In its statement, the Ministry of Economic Affairs and Employment considers it important that the risk factors related to the possible continuation of use and decommissioning, and the effects of the plant's ageing, are investigated, and that the means of preventing or mitigating the effects are carefully assessed. STUK will assess the safety of continued use or decommissioning later in connection with the processing of the licence application. The Ministry believes that the report should - closely describe the methods by which ageing is monitored and how the consequences of ageing will be reduced. - In particular, the methods for preventing potential risks of an accident due to ageing and therefore major emissions, such as the ageing of the pressure vehicle, should be described. - The report should also address the application of the BAT principle in reducing or preventing emissions.	Radiation safety, including the assessment and improvement of nuclear safety and accident risks, are discussed in Chapter 7. Ageing management and maintenance, as well as the related aspects to be investigated, developed and improved, are discussed in Chapter 4.1. The measures and methods are also discussed in Chapter 7.8 (Assessing and improving safety and security) and Chapter 9.10.4 (Environmental impact of extended operation). Ensuring the implementation of the BAT principle is discussed in Chapter 4.12.3.
5.2.2 Cooling water supply, water construction, impacts on water bodies and their lives	
According to the assessment programme, the most significant environmental impact of continued use is the thermal load on the local sea area due to the restoration of cooling water. In connection with Option VE1, possible hydraulic works in front of the cooling water intake structure and in the near-sea area have been described. The aim is to reduce the temperature of the cooling water to be taken and possibly restored. The programme has identified environmental impacts from dredging, mining and the construction of a new embankment structure related to water construction.	The water engineering projects were removed from the assessment procedure on the grounds of techno-economic investigations; the matter will continue to be reviewed in Fortum's internal project (Chapter 9.16.8).
The effects related to the taking of cooling water were highlighted in several opinions. It would be particularly important that the procedure assesses all measures to reduce the thermal load on the sea. The assessment procedure should also take into account the effects of warming seawater caused by climate change on the temperature of the water returned to the sea.	The baseline data and assessment methods used in the cooling water modelling are described in Chapter 9.16.2 and Appendix 4. The means by which to mitigate adverse impacts are described in Chapter 9.16.8.
The statements suggested that the amounts of artificial radioactive substances in sediments in the dredging area should be investigated, and that their possible release in connection with dredging work should be assessed. The report should likewise specify information on the harmful substance study of the sediment, the impact of waterworks (such as a new embankment structure) on flow conditions and the cooling water modelling as well as the impact that changes in the flow fields would have on the migration of radioactive substances.	The impacts of dredging and water engineering works have not been assessed because the operations were not included in the environmental impact assessment (see above). The sediments are monitored as part of Fortum's radiation control programme (see Chapter 9.8.3.4).
The statements pointed out that the combined effects of various factors such as thermal load, water turbidity and nitrogen emissions should be taken into account when assessing water impacts. The impact on the lives of water bodies should also be accounted for. The precautionary principle should be complied with, and activities in spawning and occurrence areas important to fish stocks, for example, should be avoided.	The impacts on the sea area are assessed in Chapter 9.16. The assessment considers the combined effects and the impact on the aquatic organisms.

Main points given in the statement by the coordinating authority	Consideration in the EIA Report
The domestic water of Loviisa nuclear power plant is currently taken from Lappomträsket lake. It is important to investigate the impact that the different project options would have on Lappomträsket lake, its surroundings and Lappominlahti bay.	The impacts on Lappomträsket lake are assessed in Chapters 9.16.4.7 and 9.16.5.7.
The Ministry of Economic Affairs and Employment considers that the effects of cooling water are the most significant environmental impacts of the nuclear power plant during normal operation. When considering the environmental impacts of the thermal load, the available information must therefore be widely exploited. - The modelling must also take into account the impact of climate change on the plant's environmental load. - The calculation of the environmental load due to cooling water should be presented conservatively, and the results in an illustrative manner. - The Ministry also notes that the environmental impact assessment concerning water bodies should not be limited to cooling waters, but should be assessed for the operations of the entire plant.	The modelling results are presented in Appendix 4 and Chapter 9.16 (impact assessment concerning waterways) of the EIA Report. The modelling accounted for the impact of climate change and the results were presented conservatively and illustrated with figures. The impact on waterways in terms of the entire plant's operations are assessed in Chapter 9.16.
5.2.3 Exceptional and accident situations	
The Ministry of Economic Affairs and Employment received several statements which drew attention to the accident modelling concerning a severe reactor accident presented in the assessment programme. The Ministry of Economic Affairs and Employment states that in Finland (section 22b of the Nuclear Energy Decree), a high emission limit value of 100 TBq for caesium-137 has been set, and this value has been used as a source term, which describes the accident in the INES 6 category in Finnish environmental impact assessments. However, a number of statements and opinions suggested the inclusion of a more realistic source term in the reviews to be made. The Ministry considers that it is appropriate for the project owner to provide a comparison between the source term used and a more realistic emission estimated for the installation under consideration. At the same time, the party responsible for the project should also examine the safety principles of the installation aimed at preventing high emissions in the event of serious accidents.	The modelling of a severe reactor accident was conducted according to plan. The emission would consist of a total of 200 nuclides or states. The emission would release 100 TBq of the Cs-137 nuclide and other radionuclides in equal proportion to what would be expected to be released in proportion to caesium-137 in the accident. As a more realistic emission, the assessment included a review of an accident in which a major leak from the primary system to the secondary system occurred. The classification of incidents and accidents, and the requirements concerning them, are discussed in Chapter 7.4. Safety principles are presented in Chapter 7.5. The modelling of a severe reactor accident is discussed in Chapter 9.21, and transboundary impacts in Chapter 9.24. Other incidents and accidents are discussed in Chapter 9.22, and their combined effects with other projects in Chapter 9.23.
In addition, the Ministry of Economic Affairs and Employment states that the impact assessment of exceptional and accident situations should not be limited to the protection zone or the emergency preparedness area. In accordance with the EIA Decree, the EIA report must present accident situations causing different emissions and describe, by means of illustrative examples, the extent of the affected areas and the impact of emissions on humans and nature.	The impacts of a severe reactor accident were assessed up to a distance of 1,000 km (Chapters 9.21 and 9.24). The impacts of a more realistic accident (a major leak from the primary system to a secondary system) were assessed up to a distance of 100 km (Chapter 9.22).

Main points given in the statement by the coordinating authority	Consideration in the EIA Report
5.2.4 External threats	
The Ministry of Economic Affairs and Employment states that the project's external threats and the risks arising from climate change must be taken into account when assessing the safety of the project. STUK will assess the safety of the project later in connection with the processing of the licence application. However, the Ministry of Economic Affairs and Employment considers that the analysis should assess the phenomena caused by climate change at the plant site and the preparedness for them.	The impacts of climate change are discussed in Chapter 9.12 and in the impact assessments concerning surface waters and aviofauna (Chapters 9.16–9.17). Preparedness for external threats and climate change is addressed in Chapter 7.5.6.
5.2.5 Impacts on the climate	
It would be important to describe the climate impacts of the project under a separate heading in the assessment report, broken down by construction and decommissioning and long-term impacts. In the case of climate impact assessments, it should be specified whether the impacts of the nuclear fuel production chain and spent fuel disposal are included in the review, and it would also be a good idea to relate the direct climate impacts of project options not only to national climate objectives but also to regional targets.	Climate impacts in terms of extended use and decommissioning are described in Chapters 9.12.4 and 9.12.5. Chapter 9.12.4 discusses the greenhouse gas emissions of various forms of energy production over their lifecycles. Climate impacts were also reviewed in relation to the climate targets.
The statements drew attention to the fact that the assessment procedure should also account for the environmental impact of fuel supply. The carbon dioxide emissions of different forms of energy production should also be compared – with consideration for entire lifecycles – in a table, for example.	The environmental impact of the procurement of nuclear fuel is discussed in Chapter 9.9.4. Chapter 9.12.4 discusses the greenhouse gas emissions of various forms of energy production over their lifecycles.
The statements pointed out that the method for calculating the project's carbon dioxide emissions should be specified in the assessment report. In addition, accounting for climate change is important, especially in the case of decommissioning.	The calculation method is described in Chapter 9.12.2.
The Ministry of Economic Affairs and Employment considers it appropriate for the project owner to examine the climate impacts through the greenhouse gas emissions of operations and to compare different forms of energy production, taking into account the lifecycle of different fuels.	Greenhouse gas emissions and climate change are discussed in Chapter 9.12.
5.2.6 Energy markets	
The statements on the EIA programme drew attention to the forecasts concerning Finland's electricity production and consumption. The power plant's share of Finland's electricity production should be presented more transparently, including a long-term forecast on the development of the power plant's share and the Finnish electricity market. The procedure should also deal with different scenarios of future electricity needs and the project's overall economic impact. The Ministry of Economic Affairs and Employment notes the following in terms of the submitted statements: the examination of the effects on the electricity market, taking into account the timing of the different options, is appropriate. The results and the starting points of the report must be clearly and transparently expressed. The Ministry also notes that the party responsible for the project is a company producing and selling electricity. It is for the state to carry out nationwide reviews of energy supply. In addition, the Ministry notes that the Government, under the leadership of the Ministry of Economic Affairs and Employment, is currently preparing a new national climate and energy strategy with the aim of carbon neutrality in Finland by 2035, in accordance with Prime Minister Sanna Marin's Government Programme.	The impacts on the energy markets and security of supply are reviewed in Chapter 9.11. The impacts on the regional economy are assessed in Chapter 9.13

Main points given in the statement by the coordinating authority	Consideration in the EIA Report
5.2.7 Impact of continued use on nuclear waste management	
The continued operation of the power plant will increase the accumulated total amount of low- and medium-level waste and spent nuclear fuel. However, as a rule, the methods of nuclear waste management would remain the same, and the existing capacity of the L/ILW repository is also estimated to be sufficient for the disposal of nuclear waste resulting from continued use. However, according to the GTK, the extent of the excavation in the case of continued use is unclear, and the assessment programme does not sufficiently explain the requirements that the increase in intermediate-level waste in particular sets for excavating additional space in the L/ILW repository.	The excavation volume of the required additional space is discussed in Chapters 5.2.1 and 9.10.5.2, among others. The volume of intermediate-level waste to be generated during the extended operation is discussed in Chapter 4.7.
The Uusimaa ELY Centre states that it is important to describe in the assessment report which option will be used to assess the environmental impact of the increase in the interim storage capacity for spent nuclear fuel. According to the Swedish Radiation Authority, the EIA procedure should emphasise the increase in the interim storage for spent fuel, as this increases the possibility of releasing long-life nuclides. Natur och Miljö rf suggests that if the interim storage of spent fuel is carried out by placing fuel in the storage pools more frequently, the alternative must be described in the assessment report with sufficient accuracy to ensure safety.	Both options for interim storage are described in Chapter 4.6.
Following the interim storage, the intention is to deposit the spent nuclear fuel for final disposal in Posiva Oy's final disposal facility in Olkiluoto, Eurajoki. STUK's statement points out that more spent fuel would be generated in connection with the possible continuation of use than previously taken into account in the licence procedures for the Posiva disposal project. However, Posiva Oy notes in its own statement that the decision-in-principle and construction licence granted for the disposal project enable the final disposal of fuel, taking into account the aforementioned fuel increase.	The volume of spent nuclear fuel is discussed in Chapter 5.9, and the impacts of the increased volume in Chapter 10.2.2.
The safety of the final disposal of spent nuclear fuel was called into question in the Austrian statement, and in a number of statements by organisations and citizens. In particular, studies on the KBS-3 method on the premature corrosion of copper capsules were highlighted, and Austria noted that this should be commented on in the assessment report. Greenpeace also argued that nuclear waste management should generally be dealt with more comprehensively in the procedure, in particular in respect of final disposal.	The environmental impacts of the final disposal of spent nuclear fuel are assessed in the separate EIA drawn up by Posiva Oy, and these impacts are referred to briefly in Chapter 9.10.5.1 of this EIA Report.
The Ministry of Economic Affairs and Employment states that despite the increase in the amount of nuclear waste caused by continued use, the methods of nuclear waste management will remain the same as a rule, and it will be possible to increase the necessary capacity. The Ministry periodically assesses the effects of the increase in low- and intermediate-level nuclear waste and spent fuel as part of the Loviisa nuclear waste management package. If necessary, the increase in the amount of spent nuclear fuel and its impact on Posiva Oy's operations must be taken into account. STUK will assess the safety of nuclear waste management in connection with the processing of the possible operating licence applications for Loviisa nuclear power plant. In addition, STUK will assess the safety of the final disposal of spent nuclear fuel in connection with the processing of Posiva's operating licence application. In the Ministry's view, it is sufficient at this stage for Fortum to ensure that the investigation related to corrosion of the copper capsule is carried out, e.g. by Posiva Oy as part of the preparations for the operating licence phase of the encapsulation and final disposal. In addition, the report must specify the option based on which the environmental impact of the increase in intermediate storage capacity for spent nuclear fuel is assessed.	The increase in the volume of spent nuclear fuel is addressed in Chapters 5.9 and 10.2.2. Posiva will present the long-term safety case for the final disposal of spent nuclear fuel in connection with its application for an operating licence (Chapter 9.10.5.1). Both options for interim storage are described in Chapter 4.6. The comparison is made in Chapter 10.2.2. The differences between the options are minor (Chapter 9.10.4.1).
5.2.8 Decommissioning and independence of spent fuel intermediate storage facility, liquid waste storage facility, solidification plant and L/ILW repository	
In the Ministry's view, the decommissioning part of the programme is sufficient. The Ministry evaluates the updated decommissioning plan for Loviisa nuclear power plant periodically. The decommissioning plan also discusses the radiation protection planning for personnel. In its previous assessment, the Ministry drew attention to the coverage of the plan with regard to the use of independent plants and preliminarily, their decommissioning. The final decommissioning plan for Loviisa nuclear power plant will be approved by STUK during the decommissioning licence phase.	Decommissioning is discussed in Chapter 5, the operation and decommissioning of the plant parts to be made independent in Chapter 5.4, and the environmental aspects of decommissioning in Chapter 5.8.

Main points given in the statement by the coordinating authority	Consideration in the EIA Report
5.2.9 Expanding, operating and closing the L/ILW repository	
Among other things, the statements on the EIA Programme note that that the assessment should examine the need to update the Hästholmen rock model, especially from the perspective of water-conducting structures, and that the design of the extension must be based on up-to-date structural and hydrogeological data. The volume of the leakage water accumulated in the rock spaces must also be assessed, and the utilisation of the quarry material resulting from the expansion of the L/ILW repository must be specified. The need to update environmental impact monitoring programmes must also be specified in terms of the impact of the various options. Based on the statements given, the Ministry of Economic Affairs and Employment considers it important that the project owner assess the timeliness of models describing the soil, bedrock and groundwater conditions, the amount of leakage water accumulated in rock spaces and the need to update the monitoring programme. The utilisation of the quarry resulting from the expansion of the L/ILW repository should also be specified in the report. The expansion of the L/ILW repository is significant compared to the existing scope. The service life of the L/ILW repository will be extended beyond the current operating licence in the options presented. A longer service life requires that a new operating licence for the repository be applied for. The current operating licence for the L/ILW repository is valid until 2055. It is the view of the Ministry of Economic Affairs and Employment that it is advisable to make the future licence procedure for the L/ILW repository clear in the report, taking into account the need to expand the repository and the total amount of radioactive waste to be disposed of with a licence. If possible, the closure of the repository must also be taken into account in the length of the operating licence, as, according to the current Nuclear Energy Act, disposal facilities will be closed under the operating licence. STUK will assess the long-term safety of the L/ILW repository in connection with the operating licence procedure.	The expansion of the L/ILW repository and the interim storage of the quarry material are discussed in Chapter 5.2, and the environmental aspects of the expansion are identified separately in the sub-chapters of Chapter 5.8. The environmental impacts are assessed in Chapter 9. The rock model used for the calculation of groundwater flows was updated for the 2018 safety case, and took the latest information into account (Chapters 9.14 and 9.15). The safety case also reviews the expanded spaces (Chapter 9.10.5.2). The monitoring programmes are discussed in Chapter 11, and the bedrock and groundwater conditions in Chapters 9.14 and 9.15. Seepage waters are reviewed in Chapter 9.15, and the reuse of the quarry material in Chapter 9.9 The licensing procedure for the L/ILW repository is addressed in Chapter 12.1. The tentative schedules of the project options account for the closure of the L/ILW repository (Chapter 3).
5.3 Nuclear waste management cooperation	
Options VE1 and VE0+ include the possibility of receiving, handling, placing in interim storage and depositing for final disposal small amounts of radioactive waste generated elsewhere in Finland. In the view of the Ministry of Economic Affairs and Employment, there must be a treatment and disposal route for all radioactive waste generated in Finland. The treatment and disposal of waste generated elsewhere in Finland in the Loviisa nuclear power plant area would significantly complement the national waste management of radioactive materials. The Ministry is of the opinion that the project owner can specify the information on the properties of waste highlighted by STUK in the assessment report only in a fairly general way. STUK will assess the safety of the management of radioactive waste generated elsewhere in Finland as part of Loviisa nuclear power plant's waste management package in connection with the licence procedures for Loviisa nuclear power plant and the L/ILW repository.	Other radioactive waste is described in Chapter 6.2 at the currently possible general level. The environmental impacts of the reception of radioactive waste generated elsewhere in Finland are assessed in Chapter 9.
5.4 Competence of the project owner and the coordinating authority **5.5 Plan for organising the assessment procedure and related participation** **5.6 Schedule of the EIA procedure**	
The coordinating authority's statement did not mention matters that would require separate consideration in the environmental impact assessment.	Nothing to consider in terms of what is presented in the programme.



APPENDIX 4

Impact of Loviisa power plant's intake and discharge of cooling water on sea area

1. Introduction

This report concerns the impact that an extension of Loviisa power plant's operation in its current form would have on the temperature of the surrounding sea area. Dispersion model calculations provide the best way to assess the impact of the discharge of cooling water. The review is carried out using three-dimensional hydraulic modelling, which involves the calculation of the water's temperature and salinity stratification when the power plant is in operation, and when the power plant is not in operation. The thermal effect that the power plant's operation has on the surrounding sea areas is arrived at by comparing the modelling results. The model's initial values, boundary conditions and environmental constraints at the time of the calculation have been obtained from environmental measurements. The modelling results are also compared to earlier cooling water modelling and observations. The review also examines whether the modelling indicates any thermal effect on the Natura area in the vicinity of the power plant which would be attributable to the warm cooling water.

The seawater used for cooling by Loviisa power plant is taken from Hudöfjärden, west of the island of Hästholmen, and the warmed cooling water is discharged into Hästholmsfjärden, east of the island of Hästholmen and connected to the outer archipelago through narrow straits (Figures 2-1 and 2-2). While the general eutrophication trends of coastal areas in the Gulf of Finland (HELCOM 2018) have been visible during the summer monitoring of the aquatic flora in the power plant's surroundings, so has the warming effect of the cooling waters. In the winter, the warmed cooling water weakens the ice cover on the discharge side.

The modelling has been carried out separately for both ice-free and ice seasons. With regard to the ice-free season, the modelling examines the impact that the power plant's operation had on the temperature of the surrounding sea area in the conditions of 2011, because more extensive temperature measurements of the seawater were conducted in nearby areas at the time. The more extensive temperature data allow for the model's more precise calibration, while providing a good point of comparison for the modelling results. The 2011 summer was also warmer than usual, with temperature conditions nearly equal to the 2050 temperature conditions projected in climate change scenarios. By employing the 2011 environmental conditions as a basis for the modelling of the ice-free season, we can simultaneously assess the water temperature of the nearby sea areas in conditions that are likely to become more common as climate change progresses.

With regard to the ice season, the modelling is based on the environmental conditions in March 2018. The ice winter of 2017–2018 was normal, and the Baltic Sea's ice extent was at its maximum in early March 2018 (Appendix 1). The effect that the warm cooling water has on the nearby area's ice conditions is assessed by examining the ice season separately. As climate change progresses, the average extent of the ice cover and the duration of the ice season are likely to reduce (Climate Guide 2021a). Yet a significant variation in the extent of sea ice will also occur from one year to the next in the future. This means that ice winters considered normal now will probably continue to occur, although less frequently. It therefore makes sense to review the situation in terms of the ice season in the conditions of a normal ice winter, to allow the warm cooling water's effect on the ice cover to be assessed.

2. Observed area as well as intake and discharge of cooling water

Loviisa power plant is located on the island of Hästholmen, on the northern shore of the Gulf of Finland (Figure 2-1). Cooling water for the power plant is taken from the shore at Hudöfjärden, and it is discharged, warmed, in Hästholmsfjärden, on the other side of the island of Hästholmen. Figure 2-2 shows the depth of the power plant's nearby sea areas as well as the locations of the intake and discharge points. As can be detected from the figure, the local deeps and straits confine flows from one area of the sea to another.

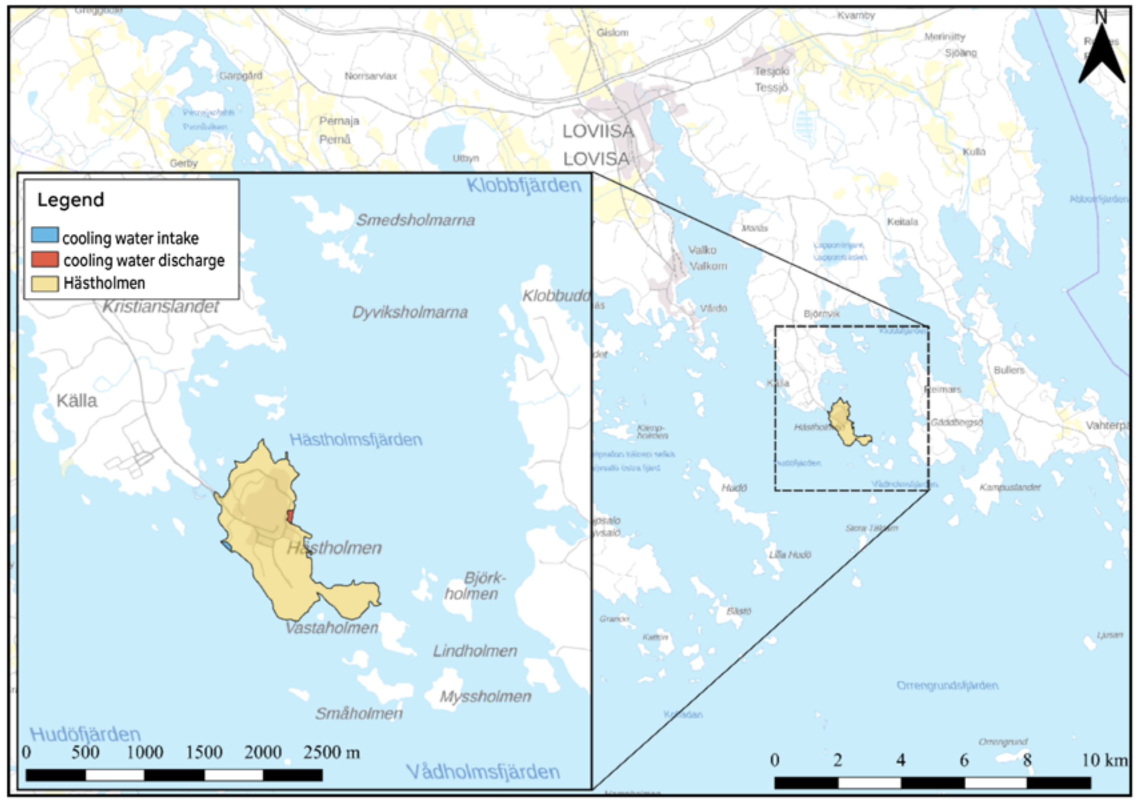


Figure 2-1. The location of Hästholmen. (Background maps: National Land Survey of Finland's 01/2021 material; scales 1:40,000 and 1:80,000)

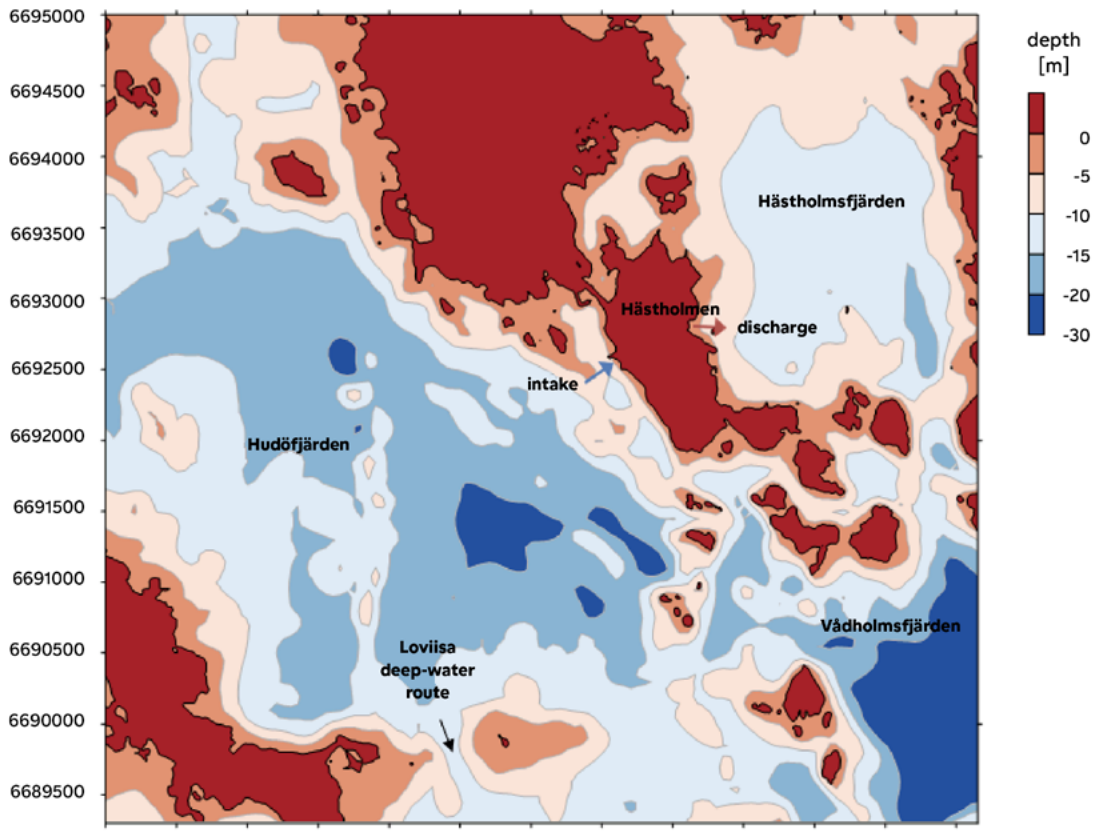


Figure 2-2. Rough depth model of Hästholmen's vicinity. The intake of cooling water is indicated with a blue arrow, and its discharge with a red arrow. The depth model has been adjusted. Coordinate system ETRS-TM35FIN.

3. Data on conditions

3.1 DYNAMICS OF TEMPERATURE VARIATION IN THE BALTIC SEA

On a longer time scale, seawater temperature in the Baltic Sea is influenced by the changing seasons – or the change in the warming effect of the sun's radiation over the course of a year. Solar radiation is at its minimum during the winter, when the seawater is also at its coldest. In winter, the sea is usually covered by an ice sheet, at least close to the shore. This slows down the exchange of water and heat between the sea and the atmosphere. In the vicinity of coastal estuaries, the river's lighter freshwater can form a bed of freshwater under the ice and thereby influence the stratification of the water body.

In spring, once the ice has melted, the sun can warm the sea's surface layer, which rapidly achieves the temperature of maximum density as it warms. When this happens, the denser water sinks to the bottom, while the lower and less dense water beneath rises to the surface – a phenomenon referred to as the water body's "spring overturn". Following the spring overturn, the surface water which continues to grow warmer becomes lighter than the cold water underneath, forming a thermocline between the thin and warm surface layer and the layer of colder water deeper down.

Over the summer, the warm surface layer of the sea grows thicker due to mechanical mixing caused by wind, and the thermocline typically achieves a depth of 5–10 m. The thermocline becomes strong during the summer, at which point the temperature can drop by 10 °C over a distance of a few metres. The existence of the thermocline also contributes to the freshwater carried by rivers staying in the surface layer, given that any vertical mixing of water through the thermocline is weak.

By the second half of August, the surface layer begins to cool down, becoming heavier than the cold water underneath and sinking as a result. Consequentially, the thickness of the homogeneous surface layer (there is very little vertical change in temperature) begins to grow, while the thermocline starts to weaken. The process continues throughout the autumn, when heat from the surface sinks deeper. Because of this, the water does not usually reach its maximum temperature at a depth of, say, 30 m until October, whereas in terms of surface water, it usually reaches it at the turn of July – August. During the autumn, an overturn of the water body occurs, at which point the temperature is the same throughout the body of water.

Very rapid changes in the temperature of seawater – in terms of both depth and time – may also sometimes take place during the summer. Rather than being directly related to seasonal temperature trends, these changes are the result of short-term weather conditions. What often lies behind rapid temperature changes in seawater occurring in the vicinity of coasts is the upwelling phenomenon, which involves a drop in the temperature of seawater on the coast, or downwelling, which involves a rise in the temperature of seawater on the coast. Upwelling and downwelling refer to the vertical movement of water caused by the dynamics of the sea, which is driven by the movement of the seawater's surface layer towards or away from the coast as a result of wind.

In an upwelling situation, the surface layer moves away from the coast, causing the removed surface water to be replaced by cool water rising to the surface. It is the reverse of a downwelling situation, in which surface water moves towards the coast and begins to accumulate in front of it, sinking more deeply. It is characteristic of upwelling for the water's temperature to change throughout the thickness of the water body during the upwelling. The temperature within a thick layer of water can also change in a downwelling situation, even throughout the thickness of the water body, if the situation is long-lasting. Water colder than the water in the rest of the sea area often accumulates in the deeps during the winter and as a result of upwelling. At the bottom, the water temperature can be as low as five degrees, whereas the surface temperature can rise to 20 °C or even higher.

In 2011, continuous observations of water temperatures were conducted at four different points and at different depths (Luode Consulting Oy 2012). The locations of the measurement points are shown in Figure 3-1. Figure 3-2 shows the measurement results of the observation points at Hudöfjärden (K1), Vådholmsfjärden (K2), Orrengrundsfjärden (K3) and the open sea (K4). The dark blue broken line in the graphs in Figure 3-2 indicates the clearest upwelling situation in the time series in question. However, other upwelling situations did occur during the period reviewed, and these are visible as situations in which the temperature of the water drops throughout, including the surface layer. The graphs show that, based on the temperature measurements, the upwelling situation is clearly distinguishable near the coast, but becomes vaguer the further from the coast we move.

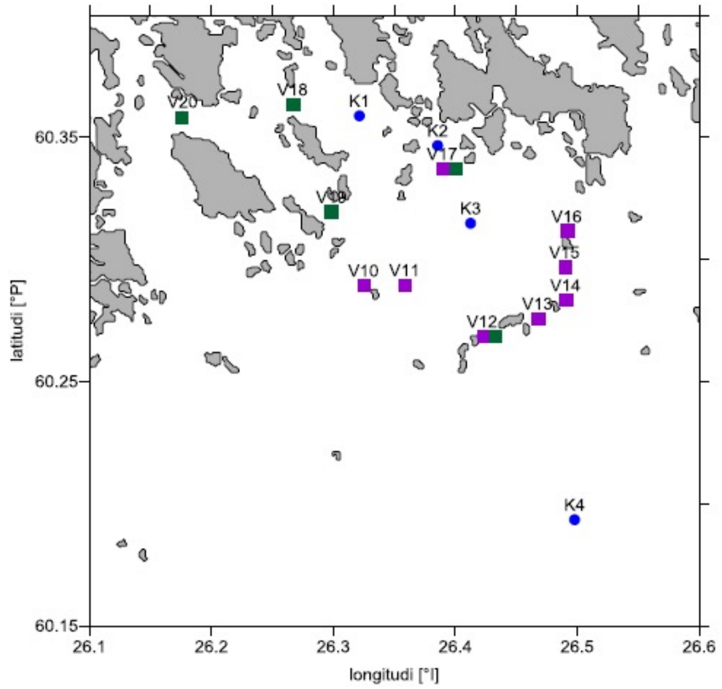


Figure 3-1. The location of the observation points (Luode Consulting Oy 2012) for water temperature at Hudöfjärden (K1), Vådholmsfjärden (K2), Orrengrundsfjärden (K3) and the open sea (K4).

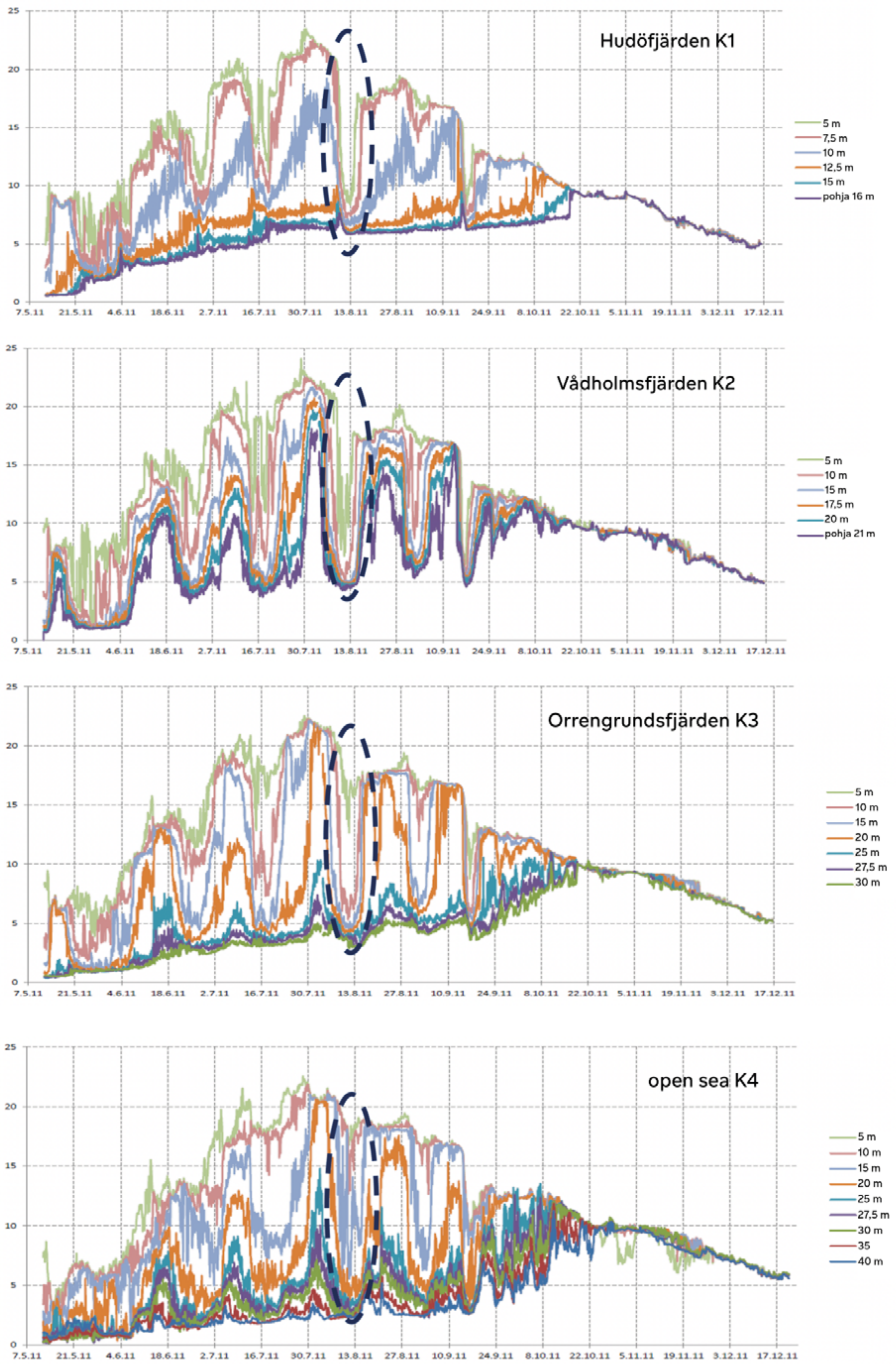


Figure 3-2. Water temperature at Hudöfjärden K1, Vådholmsfjärden K2, Orrengrundsfjärden K3 and the open sea K4, (top-down) in 2011 (Luode Consulting Oy 2012).

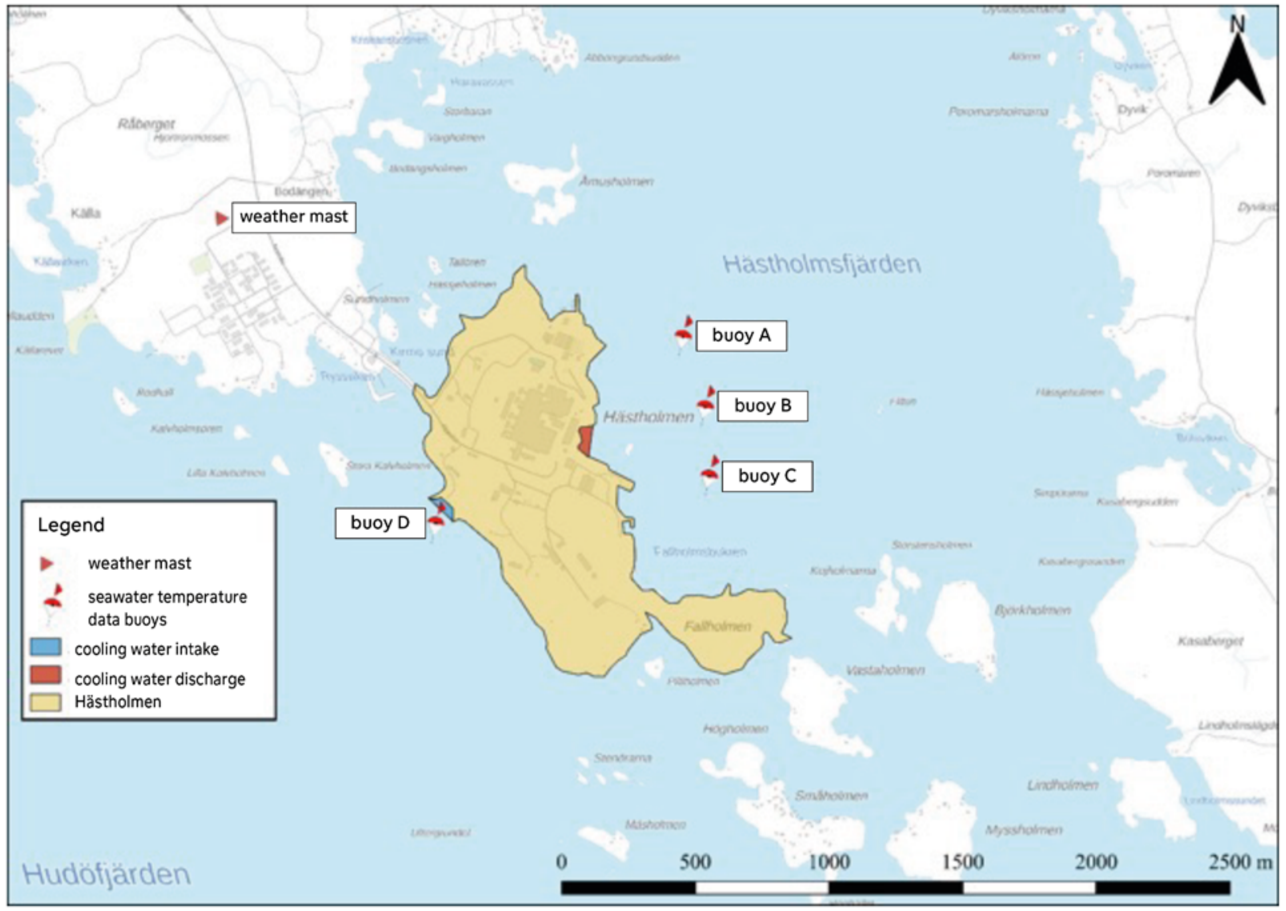


Figure 3-3. The locations of Loviisa power plant's buoys for seawater temperature measurements in front of the cooling water intake at Hudöfjärden (in red) and on the discharge side at Hästholmsfjärden (in orange). (Background map: National Land Survey of Finland's 01/2021 material; scale 1:10,000)

3.2 SEAWATER TEMPERATURE BASED ON CONTINUOUS BUOY MEASUREMENTS

Seawater temperature is measured with continuous buoy measurements in front of the cooling water intake at Hudöfjärden and in front of the discharge location for cooling water at Hästholmsfjärden. The weather mast operated by Loviisa power plant is around a kilometre northwest of Hästholmen (Figure 3-3).

The temperature observations made by the buoy roughly 80 metres from the shore perpendicular to the intake location (D) are shown in Figure 3-4. The proximity of the intake location mostly affects the temperature readings at 6 and 9 metres and to a lesser extent, measurements taken close to the surface, compared to other parts of Hudöfjärden. The warmed water is discharged into Hästholmsfjärden. Figure 3-5 shows temperature observations from 2002 taken at the temperature measurement buoys A and C in Hästholmsfjärden. The 2002 data were selected as an example because the time series of the temperature measurements of that year were the most complete. In terms of the temperature conditions, 2002 was a normal year. As can be seen from Figures 3-4 and 3-5, the seawater begins to warm in mid-March and reaches its maximum temperature at the turn of July–August. The cooling begins in late August and continues until the beginning of December.

Figure 3-6 shows the average temperature given by satellite measurements carried out in 2009. As can be seen from the figure, the southernmost part of Hästholmsfjärden, close to the power plant, is around 2–3 °C warmer than nearby areas.

3.3 SELECTION OF CALCULATION PERIOD – ICE-FREE SEASON

The temperature of seawater along the coast of the Gulf of Finland fluctuates strongly during the summer depending on time and place, as a result of upwelling and downwelling.

Due to the dynamics of the upwelling and downwelling phenomena, a description of the conditions in front of Loviisa power plant by modelling requires continuous temperature observations from several different locations and depths. Fortum has had seawater temperature measurements carried out in the environs of the power plant during several different years. The most extensive of these thus far was

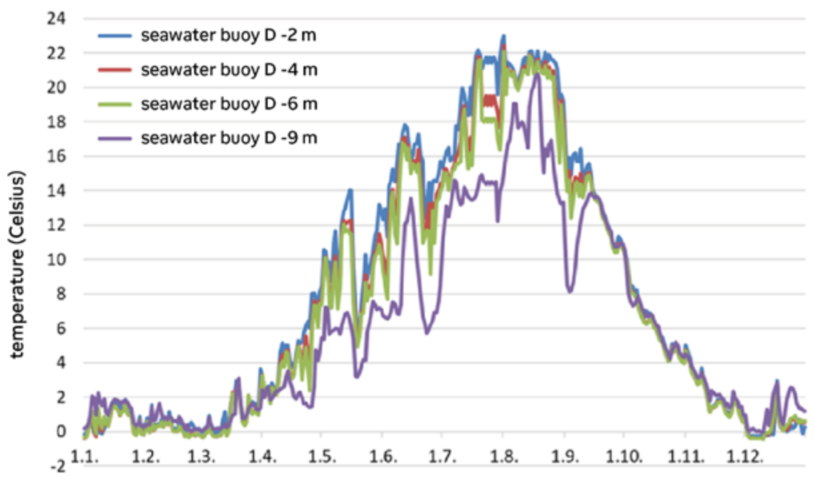


Figure 3-4. Water temperature at temperature measurement buoy D in Hudöfjärden, 80 metres from the intake location, in 2002.

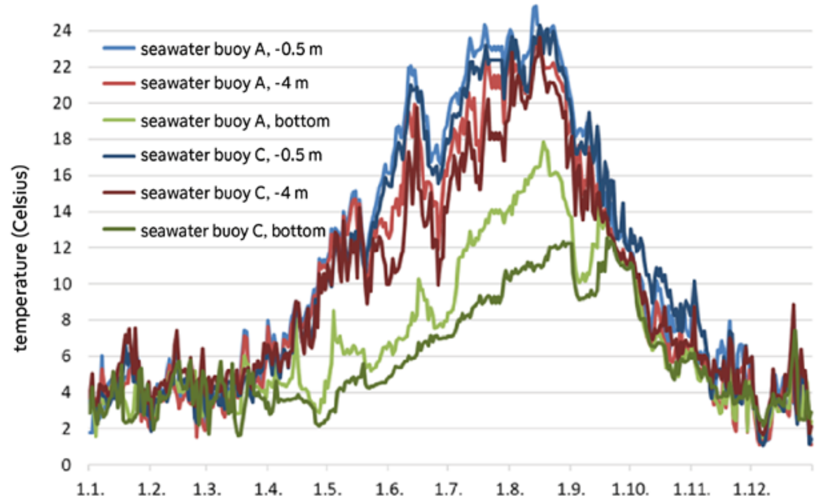


Figure 3-5. Water temperature at temperature measurement buoys A and C on the discharge side in Hästholmsfjärden in 2002.

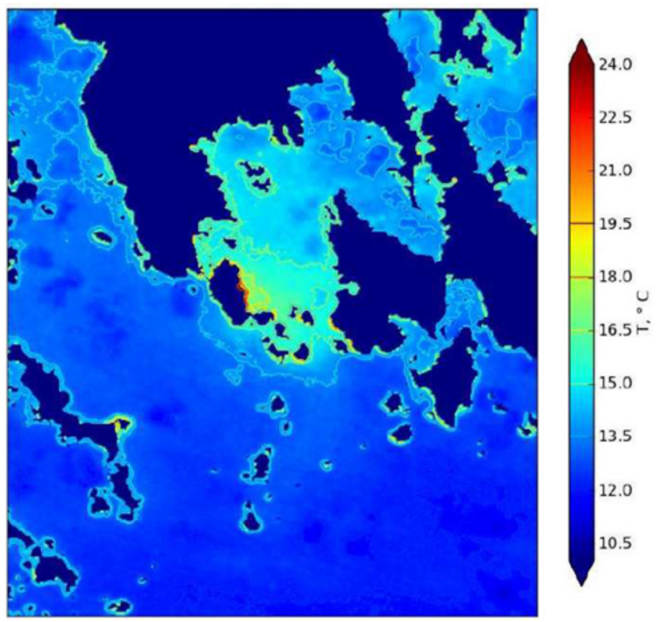


Figure 3-6. Water temperature in Hästholmsfjärden; average calculated from satellite measurements (Marjamäki 2012). The average is calculated from 11 satellite measurements conducted between 16 May 2009 and 29 September 2009.

conducted in the summer of 2011. Due to regionally extensive data on the measurement of seawater temperatures, the reviews concerning ice-free seasons employ data from the 2011 summer season, covering the period 1 June – 30 September.

The year 2011 was also unusually warm (Figure 3-7). The temperature on the southern coast was 1.5–2 °C warmer than average (1981–2000; Finnish Meteorological Institute 2020a). In Helsinki, June was 2 °C, July 3 °C and August 1.3 °C warmer than average. HELCOM reports (2007 & 2013 and BACC Author Team 2008) have projected a 2–4 (5–95% fractiles 1–6) °C increase in air temperatures for summers in the Gulf of Finland in 1961–1990...2071–2099 (Figure 3-8). According to the Intergovernmental Panel on Climate Change (IPCC 2019), the global air temperature will increase by approximately 1.0 °C (probable range 0.4...1.6 °C) by 2050 in the context of emission scenario RCP2.6 or in the context of emission scenario RCP8.5, by 1.8 °C (probable range 1.2...2.3 °C) compared to the global mean air temperature in 1986–2005 (Figure 3-9). Therefore, 2011 also depicts climate conditions which are still relatively rare in our current climate, but which will become significantly more common by the middle of this century (Climate Guide 2021b).

In 2011, the annual outages at Loviisa's power plant units were short-term refuelling outages. The annual outage of Loviisa 1 was carried out in 21 August – 7 September 2011, and that of Loviisa 2 in 10 September – 30 September 2011. The maximum temperatures of seawater in 2011 occurred in July, at which point both power plant units were in power operation (meaning that they were producing electricity for the power grid normally) when the seawater was at its warmest. Figure 3-10 shows the flow of the cooling water used by the power plant in June – August 2011 and indicates that the flow

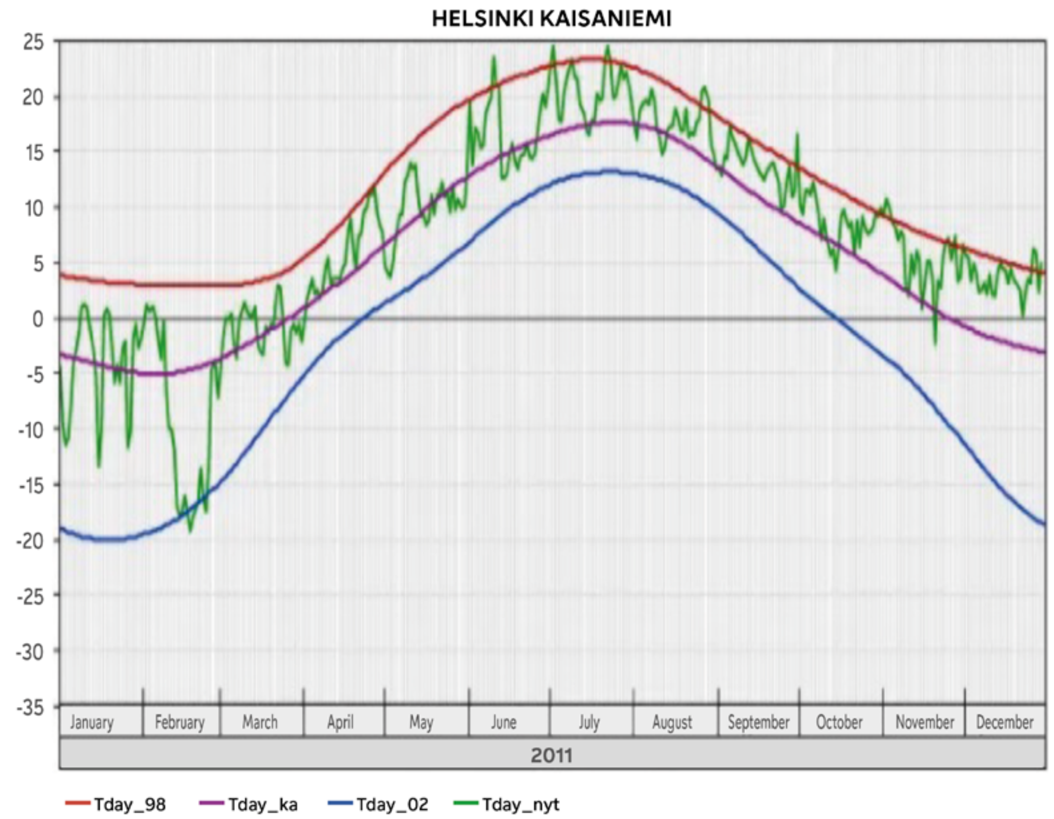


Figure 3-7. The mean daily temperature in Kaisaniemi, Helsinki, in 2011 (green) compared to the reference period (1981–2000) (Finnish Meterological Institute 2020a). Average of the reference period's mean daily temperature (purple) and 2% and 98% fractiles (blue and red).

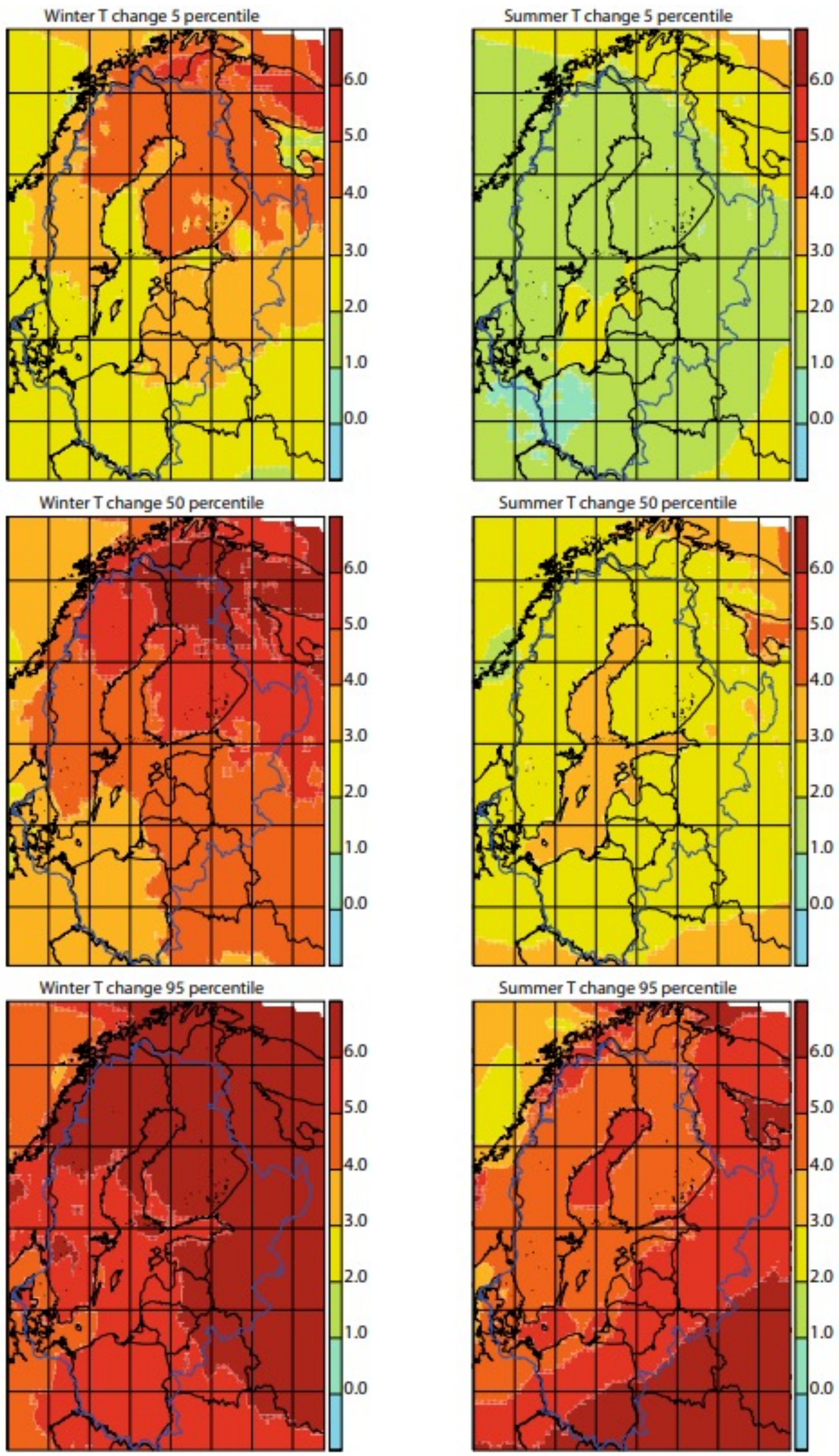


Figure 3-8. Projected change in winter and summer temperatures in 1961–1990…2071–2099 (HELCOM 2013). The left-hand column displays winter; the right-hand column summer; the fractiles from the top are 5, 50 and 95%.

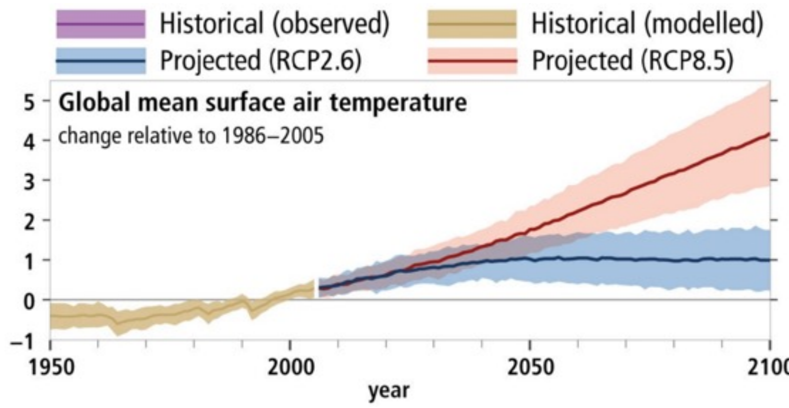


Figure 3-9. Projected change in global air temperature relative to 1986–2005. The figure has been edited from figure SPM.1 of the reference (IPCC 2019).

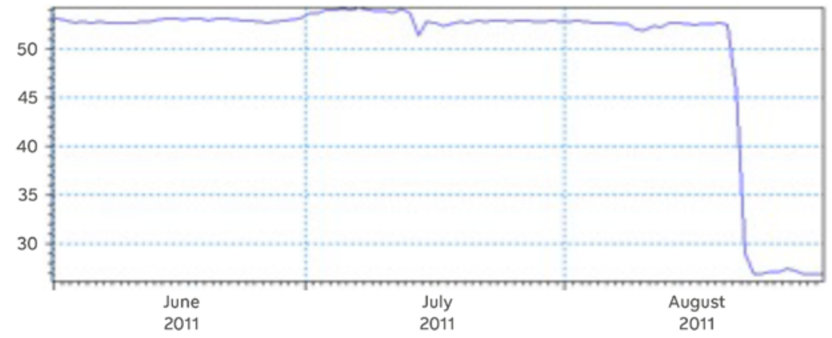


Figure 3-10. Intake flow (m³/s) of cooling water in June–August 2011.

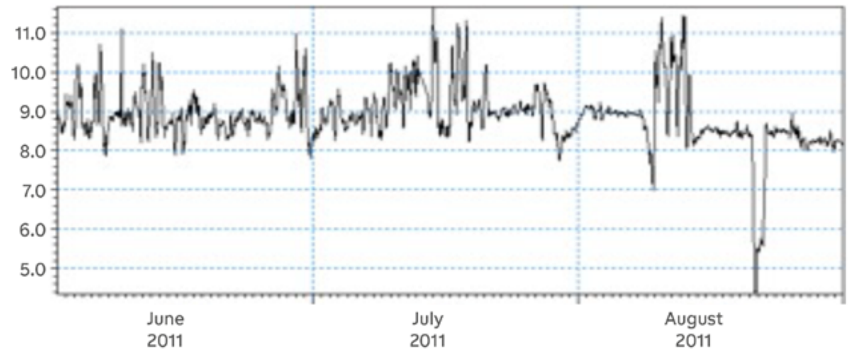


Figure 3-11. Increase in the temperature (°C) of cooling water as it passes through the power plant in June–August 2011.

during both units' power operation was approximately 52–54 m³/s. The figure also shows that the flow is nearly halved in late August when Loviisa 1 is shut down for the annual outage. Based on Figure 3-11, it can be noted that the cooling water typically warms by around 8–10 °C in the summer as it passes through the power plant.

3.4 SELECTION OF CALCULATION PERIOD – ICE SEASON

Conditions during the ice season differ from the those during the ice-free season particularly in that the warmed cooling water, being warmer than the surrounding water, can be carried along beneath the insulating ice cover for relatively long distances. The ice also prevents any mixing of the water by the wind, which can slow down the rate at which the warmed cooling water mixes with the surrounding water column. Ice cover observations which are extensive in terms of both time and place therefore constitute important baseline data for assessing the impact in the winter.

Fortum has monitored the ice cover in the surroundings of Loviisa power plant on an annual basis. The satellite photos from March 2018 (Figure 3-13) are the most applicable data for the modelling. March 2018 was relatively cold (Finnish Meteorological Institute 2020b; Figure 3-12). Although current tools do not allow for the dynamic modelling of ice cover,

Figure 3-12. Mean monthly temperatures at Kaisaniemi, Helsinki, in 2018 (columns) and the temperatures of the reference period. (Finnish Meteorological Institute 2020b)

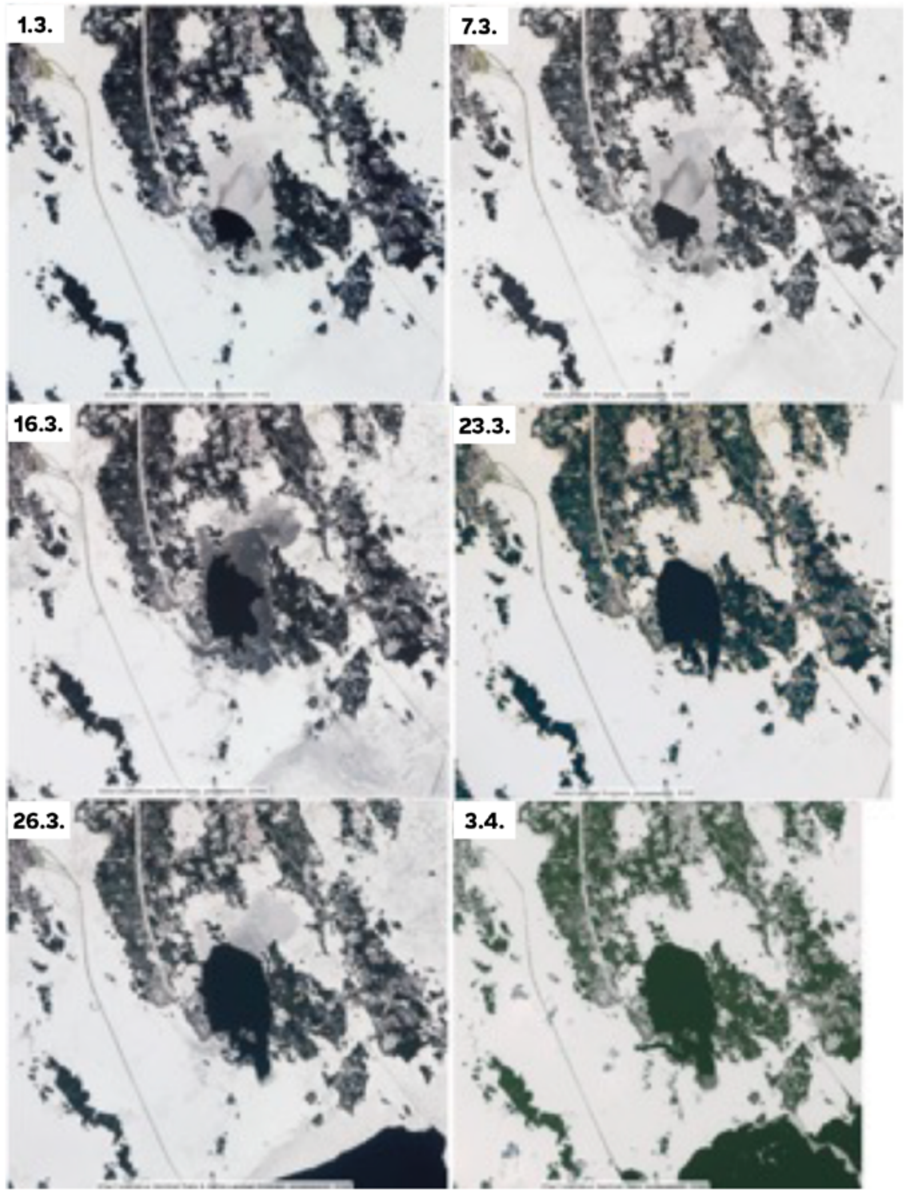


Figure 3-13. Ice cover in the surroundings of Hästholmen in the winter of 2018. The dates on which the photographs were taken are shown in the upper left-hand corner of each photograph.

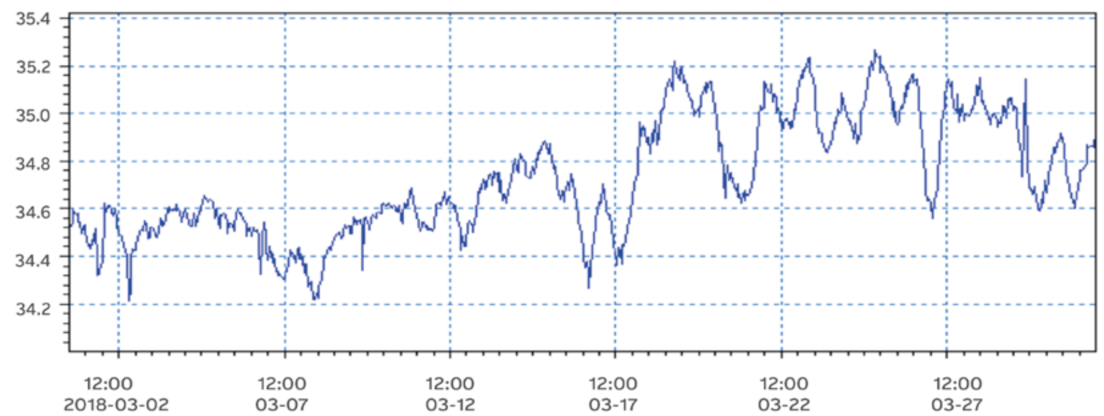


Figure 3-14. Intake flow (m³/s) of cooling water in March 2018.

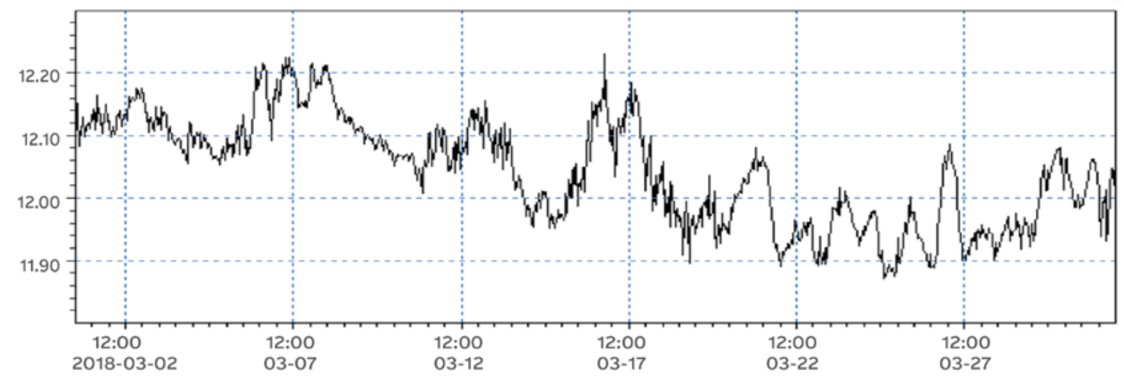


Figure 3-15. Increase in the temperature (°C) of cooling water in March 2018.

modelling with an ice cover pursuant to the observation data provides a useful conservative estimate of the dispersion of the thermal effect. The intake flow (approximately 35 m³/s) and increase in the temperature (approximately 12 °C) of the cooling water in March were normal (Figures 3-14 and 3-15).

3.5 ENVIRONMENTAL CONDITIONS

Figure 3-16 shows the monthly wind speed and air temperature averages based on the measurements of Loviisa power plant, as well as the monthly averages of cloudiness and solar radiation based on the measurements of the Finnish Meteorological Institute (Finnish Meteorological Institute 2021), employed in this report within the framework of a licence (Creative Commons 2021). The cloudiness is indicated in eighths so that 0/8 indicates a cloudless sky, and 8/8 complete cloud cover. The change in the measurement height of wind speed from 30 m to a height of 44 m (Graph 3-16 a) is the result of the modernisation of Loviisa power plant's weather observation system. The break visible in the time series of the air temperature (Graph 3-16 b) is the result of the failure of a temperature sensor. The time of the ice-free season examined in the modelling is marked on all graphs in Figure 3-16 with an orange background, and time of the ice season is marked with a blue background.

Based on Figure 3-16, one can see that the wind speeds during the times employed in the review have been fairly close to normal wind conditions. In respect of air temperature, the maximum temperatures and mean monthly temperatures of the ice-free season reviewed were the highest among the reference years. However, in respect of the ice season, the air temperatures of the review period were among the lowest within the reference years.

Figure 3-17 shows the wind rose and the wind velocity profile based on the hourly averages in 2010–2020. As Figure 3-17 a) shows, the most common wind direction in the vicinity of Loviisa power plant over a long period of time is from the southwest or east-southwest (in 28% of cases). In all directions, wind speeds are typically 0–8 m/s. The most common wind speed is 3–4 m/s (Figure 3-17 b).

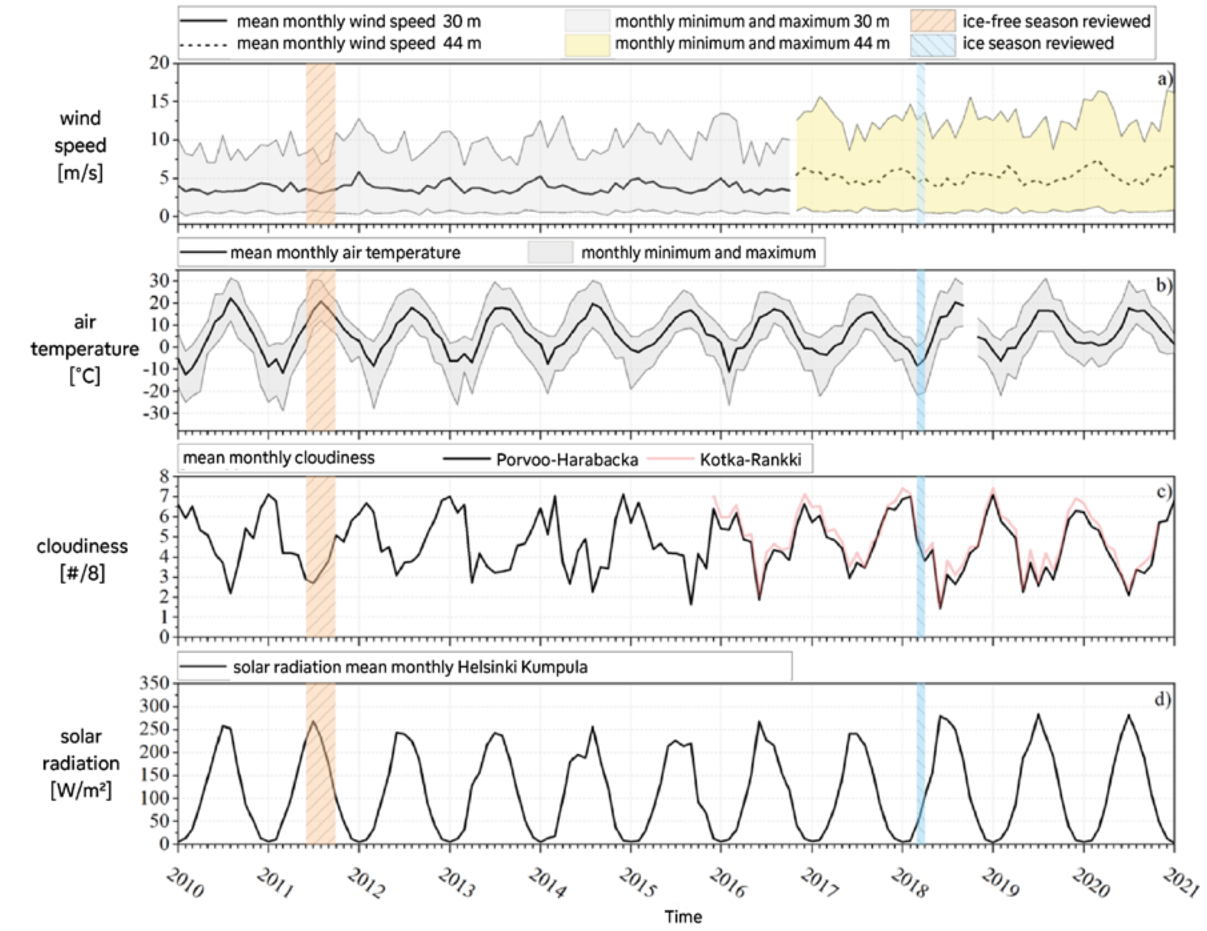


Figure 3-16. The mean monthly a) wind speed, b) air temperature, c) cloudiness and d) global solar radiation in 2010–2020. Also shown are the monthly maximum and minimum hourly averages in terms of wind speed and temperature.

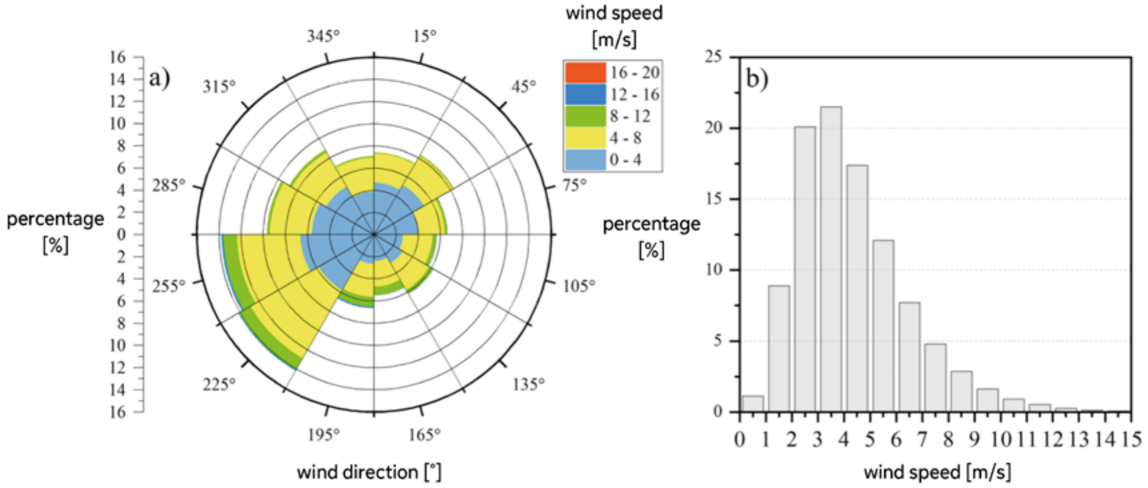


Figure 3-17. A wind rose (a) and wind speed frequency histogram (b), based on the wind measurements conducted at heights of 30 m and 44 m by Loviisa power plant's weather observation system. The measurements were carried out between 2010 and 2020.

Table 3-1 shows the annual averages of wind speed, air temperature, cloudiness and solar radiation. The higher values observed in wind speeds since 2017 are attributable to a change in the height of the measurements from 30 m to 44 m. The data in the table show that while the air temperature is 0.5 °C higher than average in terms of 2011, the annual means of other weather variables are fairly close to the average conditions in 2010–2020. In terms of 2018, the average wind speed was 0.3 m/s lower than the long-term average, and the air temperature was 1 °C lower. Despite the low mean annual temperature, the summer of 2018 was one of the warmest summers in the period between 2010 and 2020. This is also an indication that the winter at the time was colder than average, given that the mean annual temperature was low, despite the warm summer. Cloudiness was slightly below average in 2018, which partly also explains the higher-than-average values of solar radiation during the lightest time of the year and the cold conditions in the winter.

Figure 3-18 shows the wind rose and the wind velocity profile for the ice-free season reviewed in the report. The figure was prepared on the basis of the hourly averages of the wind data. Figure 3-18 a) shows that the most common wind direction is the same (southwest and east-southwest) as when observed over a longer period of time (Figure 3-17 a). In addition, the wind has blown quite often from a sector delimited by the northeast and east-southeast during the period in question. Wind speeds during the period in question were 2–4 m/s for 50% of the time (Figure 3-18 b).

Table 3-2 shows statistics calculated from the weather phenomena during the ice-free season in 2011. Based on the table, the conditions during the period in question can be seen to have been clear and characterised by light wind, due to which solar radiation has warmed the surface effectively. As a result, the air temperature during the period was relatively high.

Figure 3-19 shows the wind rose and the wind velocity profile for the ice season reviewed in the report. The figure was prepared on the basis of the hourly averages of the wind data. As can be seen from Figure 3-19 a, the wind rose for the period significantly departs from the wind conditions observed over a longer period of time (Figure 3-17 a). The most common wind directions in March 2018 were north-northwest and east-northeast, which partly explains the period's lower air temperatures. Besides the wind direction, the wind

Table 3-1. The mean annual wind speed, air temperature, cloudiness and global solar radiation in 2010–2020.

Year	Wind speed [i] [m/s]	Air temperature [i] [°C]	Cloudiness Porvoo /Kotka[ii] [#/8]	Solar radiation[iii] [W/m²]
2010	3.5	4.6	5.0	110.3
2011	3.8	6.8	4.5	116.3
2012	3.9	5.4	5.1	111.1
2013	3.8	6.5	4.5	116.7
2014	3.7	6.7	4.6	109.2
2015	4.0	7.2	4.6	108.6
2016	3.5	5.9	4.7 / 5.2	110.4
2017	5.2	5.9	5.0 / 5.3	105.8
2018	4.9	5.3	4.3 / 4.7	122.3
2019	5.1	6.7	4.5 / 4.9	118.2
2020	5.6	8.1	4.4 / 4.3	119.3
Average	3.7 (30 m) 5.2 (44 m)	6.3	4.7 (Porvoo) 4.9 (Kotka)	113.5

i) The wind speed and air temperature values are based on Loviisa power plant's weather measurements. In terms of wind speed, the results for 2010–2016 are based on wind measurements made at a height of 30 m, and the results for 2017–2020 on measurements made at a height of 44 m.

ii) The values of cloudiness are based on the cloud cover measurements of the Finnish Meteorological Institute (Finnish Meteorological Institute 2021, Creative Commons 2021). The measurements were conducted in Harabacka, Porvoo, and Rankki, Kotka. Measurements from Kotka are available as from November 2015, but in this context, only full-year results are shown.

iii) The results on solar radiation are based on the sun's global radiation measurements conducted by the Finnish Meteorological Institute at Kumpula, Helsinki (Finnish Meteorological Institute 2021, Creative Commons 2021).

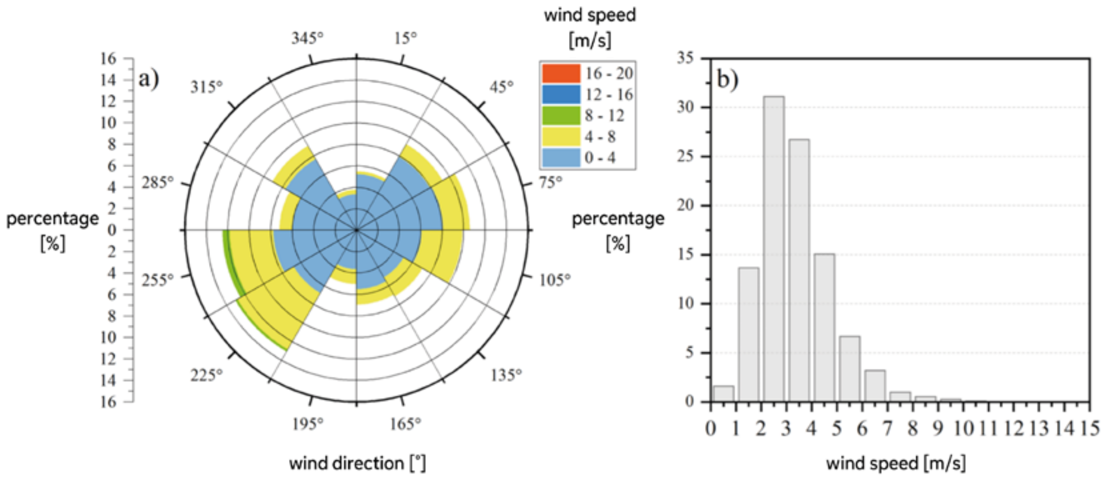


Figure 3-18. A wind rose (a) and wind speed frequency histogram (b) based on the wind measurements conducted at a height of 30 m by Loviisa power plant's weather observation system. The measurements were carried out between 1 June and 30 September 2011.

Table 3-2. Statistics on wind speed, air temperature, cloudiness and total solar radiation from the ice-free season in 1 June – 30 September 2011. The baseline data consist of the variables' hourly averages.

Statistical variable	Wind speed [m/s]	Air temperature [°C]	Cloudiness Porvoo [#/8]	Solar radiation [W/m²]
Minimum	0.4	6.0	0	-4
Maximum	10.9	30.7	8	997
Average	3.3	17.1	3.7	193.5
Median	3.1	16.8	3.7	69
Standard deviation	1.4	4.3	3.2	248.2

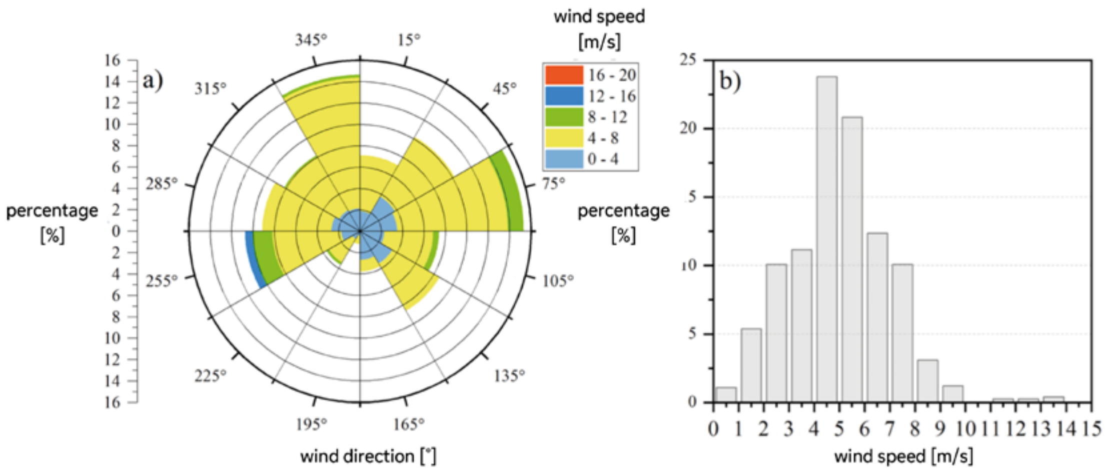


Figure 3-19. A wind rose (a) and wind speed frequency histogram (b) based on the wind measurements conducted at a height of 44 m by Loviisa power plant's weather observation system. The measurements were carried out between 1 March and 31 March 2018.

speeds also deviate from the typical long-term speeds, being somewhat higher than them. The wind speeds during the period were 4–6 m/s for 45% of the time.

Table 3-3 shows statistics calculated from the weather phenomena during the reviewed 2018 ice season. Based on the table, it can be seen that the conditions during the period in question were significantly windier than during the ice-free season. This difference is partly due to the fact that the observations carried out during the ice season employ wind measurements conducted at a height of 44 m, whereas the observations carried out during the ice-free season employ wind measurements conducted at a height of 30 m. However, March is typically a windier time of year than the summer (Figure 3-20). In terms of air temperature, the ice season was fairly cold and reasonably clear with regard to cloud cover conditions. The heightened effect of the diffuse solar radiation caused by the snow cover is visible in the readings of the sun's global radiation.

Figure 3-21 shows the interpolated sea level for Loviisa from the sea level measurements conducted at Helsinki and Hamina by the Finnish Meteorological Institute. The level is indicated relative to the theoretical mean water level. The data on Helsinki and Hamina are part of the Finnish Meteorological Institute's Open Data (Finnish Meteorological Institute 2021), used in this report within the framework of a licence (Creative Commons 2021). Although Loviisa power plant also has a sea level indicator of its own, the level assessed through interpolation from the measurements of the Finnish Meteorological Institute is better at describing the sea level conditions of the open sea, used as a boundary condition for the modelling. As can be seen from the figure, the sea level is at a quite typical level during the ice-free season,

Table 3-3. Statistics on wind speed, air temperature, cloudiness and total solar radiation from the ice season in 1 March – 31 March 2018. The baseline data consist of the variables' hourly averages.

Statistical variable	Wind speed [m/s]	Air temperature [°C]	Cloudiness Porvoo [#/8]	Solar radiation [W/m2]
Minimum	0.5	-20.5	0	-3.1
Maximum	13.7	3.0	8	669
Average	5.0	-5.2	3.8	103.8
Median	4.9	-4.6	4	0.6
Standard deviation	2.0	5.2	3.5	163.8

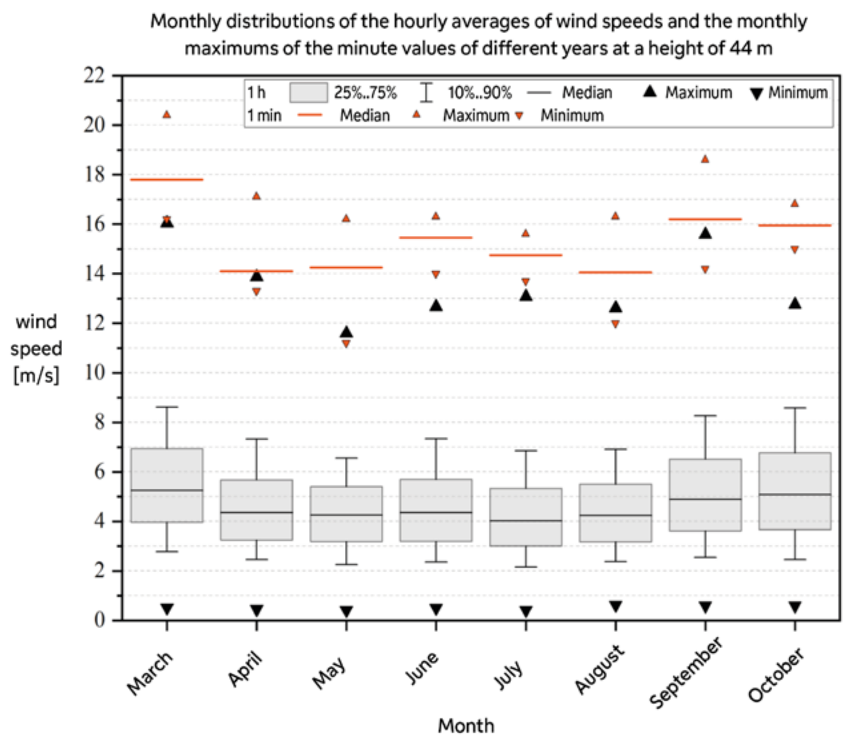


Figure 3-20. The wind velocity profile formed from the 44 m wind speed measurements of Loviisa power plant's weather observation system per month in 2017–2020. The statistics calculated from the hourly averages are marked in grey and black. The statistics calculated from the monthly maximums of a month's average wind speeds per minute are marked in red.

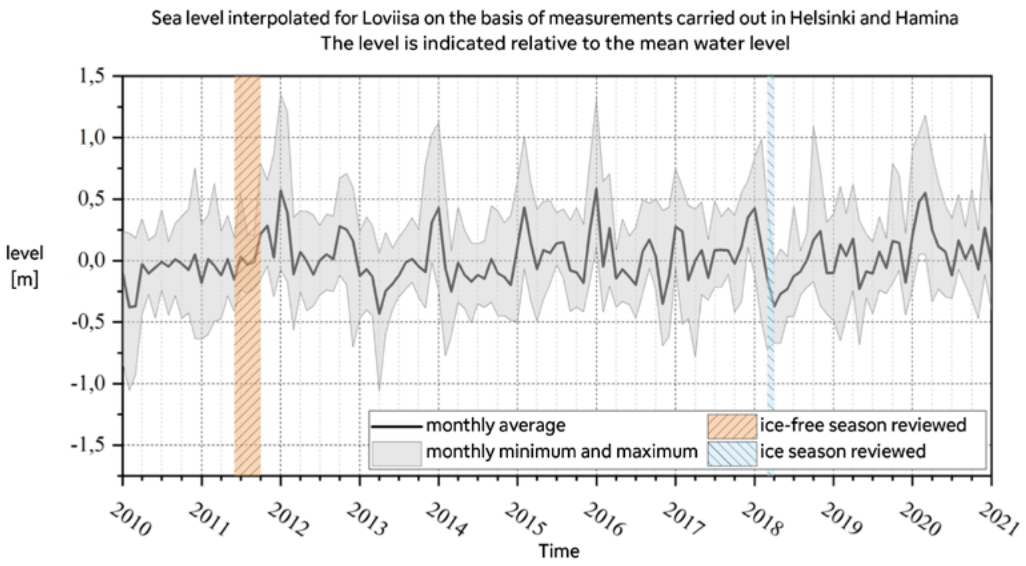


Figure 3-21. The monthly average of the sea level, as well as the minimum and maximum values for an individual hour within a month at Loviisa, relative to the theoretical mean water level.

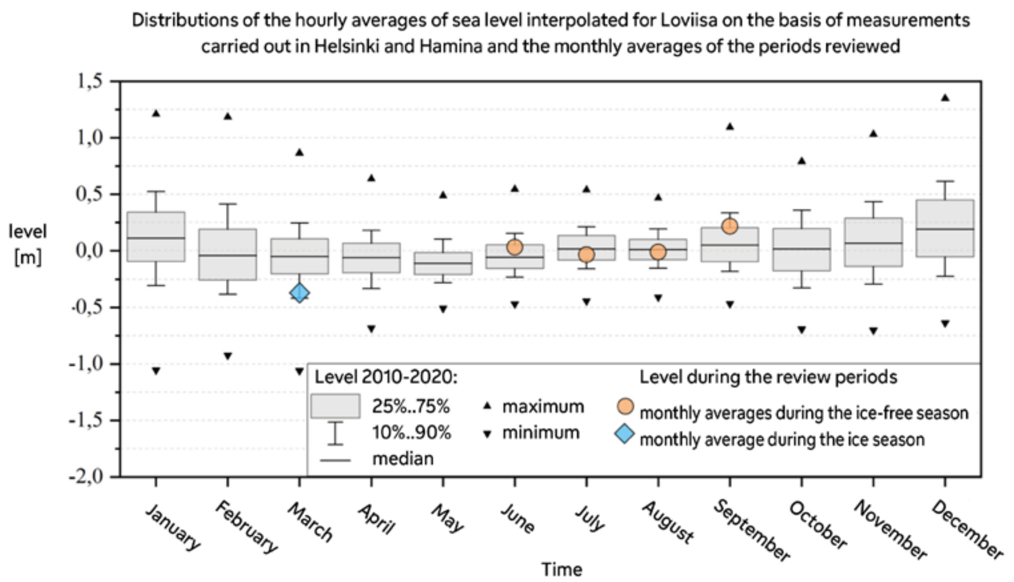


Figure 3-22. The monthly distributions of the average hourly sea levels and the monthly averages of the review periods. The sea levels are indicated relative to the theoretical mean water level.

and even the variation of the minimum and maximum levels during the period is minor. During the ice season, the sea level is at a slightly lower-than-average level, but in this case too, variation within the period is minor.

Figure 3-22 shows the monthly distributions of the average hourly sea levels and the monthly averages of the review periods for Loviisa interpolated from the sea level measurements conducted at Helsinki and Hamina by the Finnish Meteorological Institute. This figure shows more clearly than Figure 3-21 that the sea levels during the review period concerning the ice-free season are at a fairly normal level and in terms of the ice-free season, at a slightly lower-than-normal level. The figure also shows that in March, variation in the extreme sea level values is typically greater than during the ice-free season. However, in September, the variation in the extreme sea level values is typically greater than in June, July and August.

4. Description of modelling

4.1 CALCULATION EMPLOYED IN THE REVIEW

The review is based on hydraulic modelling, carried out with DHI's Mike 3 FM non-hydrostatic flow model with an adjustable computational mesh, which calculates with complete three-dimensional equations (DHI 2017); it was released in 2019. The tool allows both the hydraulics of smaller areas and the phenomena of more extensive areas to be described simultaneously. In addition to flows, the model calculates the seawater's temperature and salinity. Among other things, the baseline data consist of wind conditions, the sea level (including variations), air temperature, ice cover, and components of the net radiation of the sea and atmosphere. The modelling area extends from the coast up to Orrengrund. The model for the smaller area previously prepared for the front of the intake location was used in validating the intake location's hydraulics in terms of the more extensive model now prepared. The model's use is based on extensive and comprehensive surveys of the bottom of the sea area previously conducted by Fortum with various echo ranging methods, and the continuous observations of seawater temperature, salinity and flows, for example. The model was calibrated by comparing the calculated values to the observations made during the 2011 ice-free season. Printouts of the model's three-dimensional flowrate, temperature and salinity values were made every three hours, and the same was applied to selected points at the reviewed depths at 30-minute intervals.

4.2 MODEL'S CALCULATION GRID AND THE EQUATIONS USED IN THE MODELLING

The model's computational mesh and depth ratios are shown in Figure 4-1. The model has 1,832 horizontal elements and 1,900 nodes. The element density is at its greatest at Hästholmsfjärden and Hudöfjärden, near the power plant. The summer model has 44 element layers, of which the surface's four top ones are adjustable (Table 4-1). The winter model is identical in all respects other than there being three adjustable element layers, with the upper surface of the fixed layers at a level of -1 metres. The minimum water depth set for the model in both the summer and winter models was 1 metre. The elements of varying heights are located in the depth zone, starting immediately downwards from the varying water surface and extending to the upper surface of the fixed element layers, unless the area is shallower, in which case they extend all the way down to the seabed. The thickness of the layers was set to be distributed evenly.

Due to the requirements of the calculation, the model employed a minimum depth of one metre, given that the water level, at its lowest, dropped to a value of -0.59 m during the calculation. The intake has been carried out according to a natural width (32.8 m) and height (from a level of 8.5 m to 11.1 m), and an even flowrate in line with the flow and surface area was set for the entire area. The discharge of warm cooling water in the summer model is executed with a gate function so that the water discharges at a depth range of 0...1 m. This allows for a nearly horizontal bottom for the elements, which enables the modelling of the natural horizontal flow. In the winter model, the discharge to the surface is executed so that the water discharges from the discharge location to the surface element in an area with a depth range of 0...1 m without a gate. The difference in the execution is due to the fact that in the summer model, a geometry similar to the winter model produced an unnatural flow from the discharge into the waterway and had to be changed.

The calculation was performed by using complete Reynolds-averaged three-dimensional Navier-Stokes equations and artificial compressibility (DHI 2017). The calculation of the eddy viscosity employed Smagorinsky's Large Eddy Simulation method in the horizontal direction and the k-epsilon method in the vertical direction. The model relies on the advanced Richardson damping to describe the density layer's impact on vertical mixing. The method or its coefficients cannot be changed in the model, although stronger dampening of the kind also suggested in the literature (Elliott & Venayagamoorthy 2010) could indeed have been tried for the Gulf of Finland. The most precise possible approximations of several orders were used in the calculations of time and place, turbulence, and the transport of temperature and salinity, because although this lengthens the calculation time, it simultaneously increases accuracy. The time step could be selected from a range of 0.01–30 seconds, depending on the convergence of the iterations. The Coriolis force was accounted for in the calculations. The standard 0.5 m was used as the bed's roughness height.

4.3 MODEL'S BOUNDARY CONDITIONS AND INITIAL VALUES

In the model, the boundaries, excluding the open sea, are set as land areas, where the perpendicular flowrate has been set at zero. The boundary condition used at the open-sea boundary is the water level; the water level has been interpolated linearly from the hourly averages of the tide gauges at Kaivopuisto, Helsinki, and Hamina, using distance. The temperature and salinity boundary conditions used in the open sea were two-dimensional time series prepared on the basis of Luode Consulting Oy's automated observations and the manual observations in the environmental administration's Hertta database (Vedenlaatu/Uudenmaan ELY, Creative Commons). The river flows (Taasianjoki, Loviisanjoki, Ahvenkoski (Kymijoki), Koskenkylänjoki) are fed to the surface elements (depth approximately 0...0.5 m), with temperatures according to the Hertta service and assuming that the water salinity is zero. The values are complemented with the values of reference waterways.

The start time of the modelling calculation occurs slightly before the start of the actual review period so that the cooling water flow has time to settle into a natural state by the beginning of the review period. In terms of the ice-free sea-

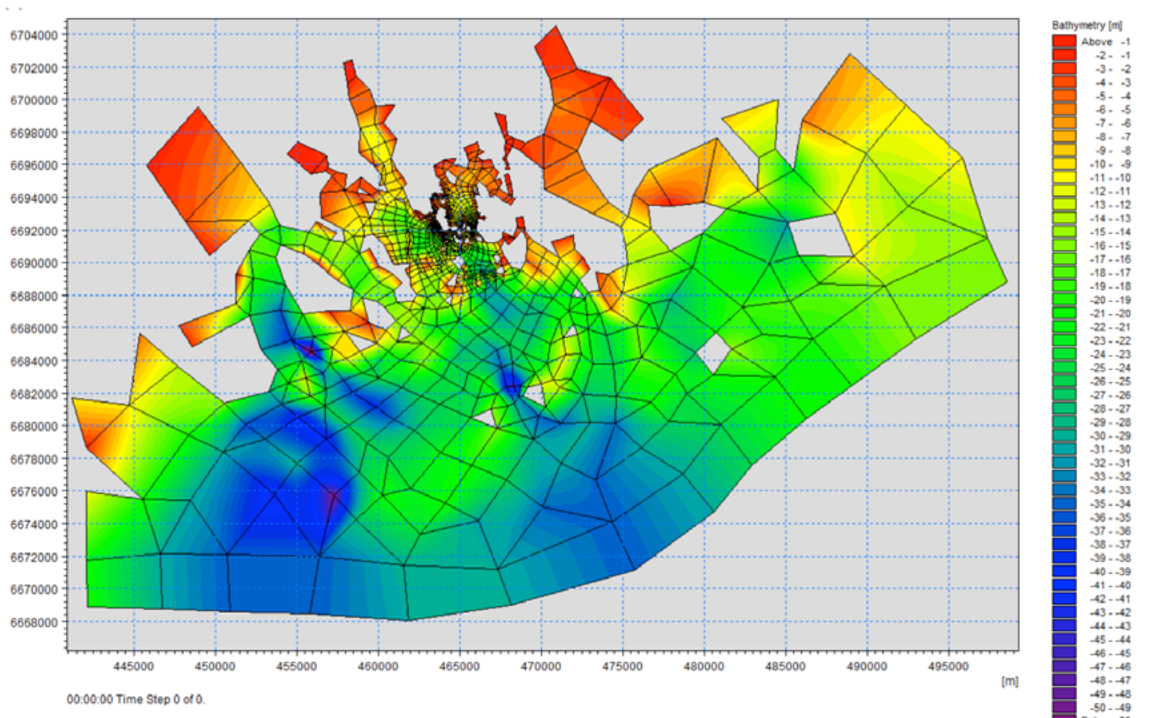


Figure 4-1. Model's computational mesh and the seabed's elevation. Coordinate system ETRS-TM35FIN.

Table 4-1. The vertical structure of the model's computational grid.

Depth (m)	Element type	Cell height
surface...2 m	adjustable 4 cells with even distribution	roughly 0.5 m
2 m...8,5 m	standard levels	0.5 m
8.5 m...11,1 m	standard levels (level of intake location)	0.65 m
11.1 m...12 m	standard levels	0.9 m
12 m...20 m	standard levels	1 m
20 m...30 m	standard levels	2 m
20 m...36 m	standard levels	3 m
36 m...40 m	standard levels	4 m
40 m...65 m	standard levels	5 m

son, the start time of the modelling calculation was 12 noon on 23 May 2011, whereas the review period actually employed in this work began on 1 June 2011. In terms of the ice season, the modelling calculation's start time was 12 noon on 18 February 2018, and the actual review period began on 1 March 2018. The initial condition employed in the model consists of the three-dimensional models of water temperature and salinity prepared on the basis of Luode Consulting Oy's (Luode Consulting Oy 2012) and the Hertta database's manual observations as well as, in terms of surface level, of the standard value for the entire area interpolated linearly from the Helsinki and Hamina tide gauges.

The longwave and shortwave radiation is described with minute averages observed in Kumpula, Helsinki. The model does not allow for the use of emergent longwave radiation calculated on the basis of water temperature. Rather, the longwave radiation emerging from the surface of the water is approximated with the help of solar radiation measurements conducted in Kumpula. During the review period concerning the ice season, the heat exchange between the water and the atmosphere in the modelling is set at zero for ice-covered areas.

The model calculation applied to the ice-free season employs the values 0.9 (Beta) and 1.4 (reduction factor) as the coefficients for the penetration depth of sunlight. These numerical values are high and typical for dystrophic and algae-rich dark waters, such as the Gulf of Finland, which is called "optically black". The model calculation applied to the ice season employs the coefficients 0.6 and 1.4, for clearer water.

The wind values for the vicinity of the power plant and the open sea were provided by Loviisa power plant's weather mast and the Finnish Meteorological Institute's Orregrund weather observation station, respectively. For the purposes of cooling water modelling, they have been converted to an elevation level of 10 m, employing a logarithmic profile conventionally used in wind conversions with a roughness class of 0.5 (Danish Wind Energy Association 2021). The atmospheric pressure, air temperature and relative humidity were provided by the Finnish Meteorological Institute's Orregrund weather observation station.

The numerical values of the wind's drag coefficient for the review periods were estimated in connection with the model's calibration. The values applied for the ice-free season are 0.315...1.12 x 10-3 linearly with a wind speed range of 0...25 m/s. These drag coefficient values are lower than the values for oceans, because the coast of the Gulf of Finland experiences waves emanating from its centre and tall waves caused by shallowness, both of which reduce the coefficients. The numerical diffusion in the model's deeper layers, which is significant compared to the extremely small natural diffusion in the sheltered coastal area, may have a coefficient-reducing impact on the results of the calibration. The use of larger coefficients would lead to an excessive vertical mixing of the temperature. Based on the calibration, the values attained for the review period concerning the ice season were 0.62...2.28 x 10-3. They are greater than the values applied to the ice-free season, because there is hardly any wave formation, and because the waves from the open sea cannot access the area either due to the ice cover.

The evaporation and condensation coefficients were also estimated in connection with the model's calibration. Dalton's coefficient 1 and Dalton's wind coefficient 1.8, as well as 5 and 0.5 x 10-3 as the coefficients for the heat convection in cooling and warming, are applied to the ice-free season. The values are typical for Arctic regions, given that the temperature differences are fairly large, and the topography varying and small-featured (Esbensen & Reynolds 1980). The coefficients may also be influenced by the fact that the model cannot apply the water's surface temperature in the transfer of the longwave infrared radiation. Large numerical values – 3, 5.4 and 10, and 0.5 x 10-3 – in accordance with the reference (Esbensen & Reynolds 1980) were arrived at as the coefficients for the ice season in connection with the calibration. This is a result of the sole ice-free area being immediately next to the discharge location, where the temperature difference of the air and water is also unusually large, and the coefficient correspondingly large. The effect of rain was not modelled, and the same applies to the transfer of heat between the bed and the water column. Nor are these components usually modelled.

Table 4-2. The scaling factor for the added vertical mixing outside the scale of the model's mechanisms and elements at different depths.

Depth (m)	Scaling factor of diffusion
0...0.15 m	0,5
1 m	0,27
2 m	0,15
3 m	0,07
4 m	0,025
4.5 m	0

The diffusion outside the model's mechanisms and scale is described with the eddy diffusion calculated by the model for each cell and moment in time. Due to the amount of natural diffusion below the thermocline, which is small compared to the amount of the model's numerical diffusion, the scaling factor calibrated for it in the vertical direction of the surface and intermediate layers is the usual 0. In the layer above the thermocline, wind increases the mixing up to a point which is significantly larger than the sum of the numerical diffusion and the diffusion described by the model, and an "advanced diffusion coefficient" was arrived at in the calibration by adjusting a logarithm-type profile deeper from the surface in accordance with Table 4-2.

In the winter calculation, the values in Table 4-2 were halved with regard to Hästholmsfjärden; this accounted for the impact of the nearby sea area's ice cover, which weakens the mixing of the water. For the open sea, outside Orrengrundsfjärden, the value was set at 0 in an attempt to reduce mixing there. At the depth level of 0...10 m, the standard value 1.1 was used as the coefficient for horizontal diffusion, excluding the open sea. The turnover of deeper water is small, because the area has many isthmuses at a depth of approximately 10 m, slowing down the water's movements. The value calibrated for the diffusion coefficient in these areas is therefore 0.

A very high value is used for the horizontal diffusion of temperature and salinity in the open sea, outside Orrengrundsfjärden, to bring the boundary condition for temperature and salinity closer. The upswelling and downswelling phenomena, which have an even decisive impact on the boundary condition at the Gulf of Finland, are transverse phenomena, which are rapidly and most clearly visible immediately next to the coast, i.e. the shoreside part of Vådholmsfjärden. However, for the precise description of the dynamics of upswelling and downswelling, the boundary condition cannot be set there, because the effect of the power plant's cooling water extends to part of Orrengrundsfjärden. The boundary condition for temperature and salinity could therefore be brought artificially, with the help of a large horizontal diffusion coefficient, only outside Orrengrundsfjärden. However, for the description of the fluctuation in the water's surface level and the wind's effect, the model's actual boundary is located further away in the open sea. This procedure allows part of the upswelling and downswelling dynamics to be described, but the description of the cooling waters' impact area and layers is precise.

4.4 MODEL CALCULATION'S VERIFICATION AND VALIDATION

4.4.1 Comparison with manual observations

Manual measurements were carried out at points 8, 9, 11 and 12 in Hästholmsfjärden (Figure 4-2) during the 1 June – 1 September 2011 modelling period. As can be observed, the

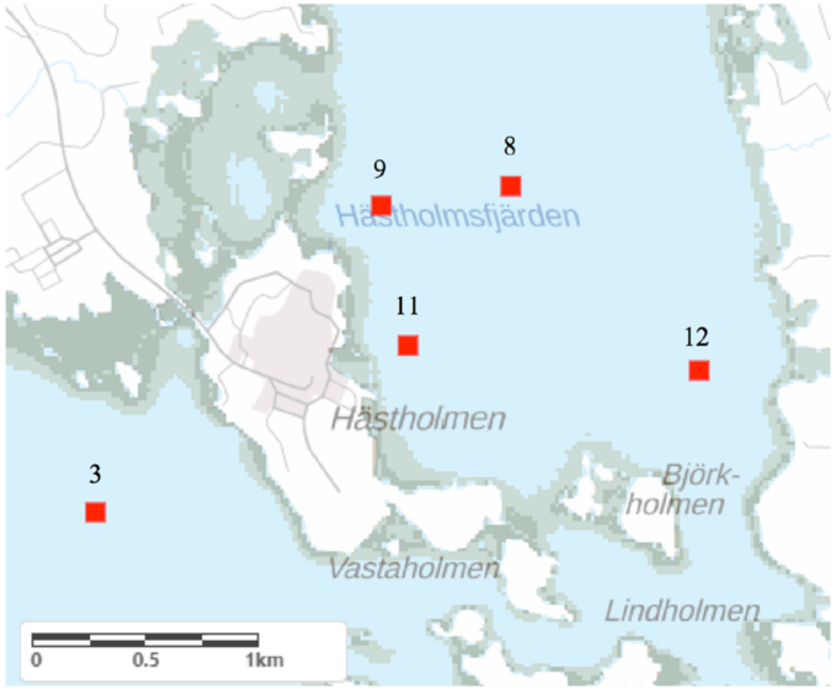


Figure 4-2. Points for the manual observation of water temperature in 2011.

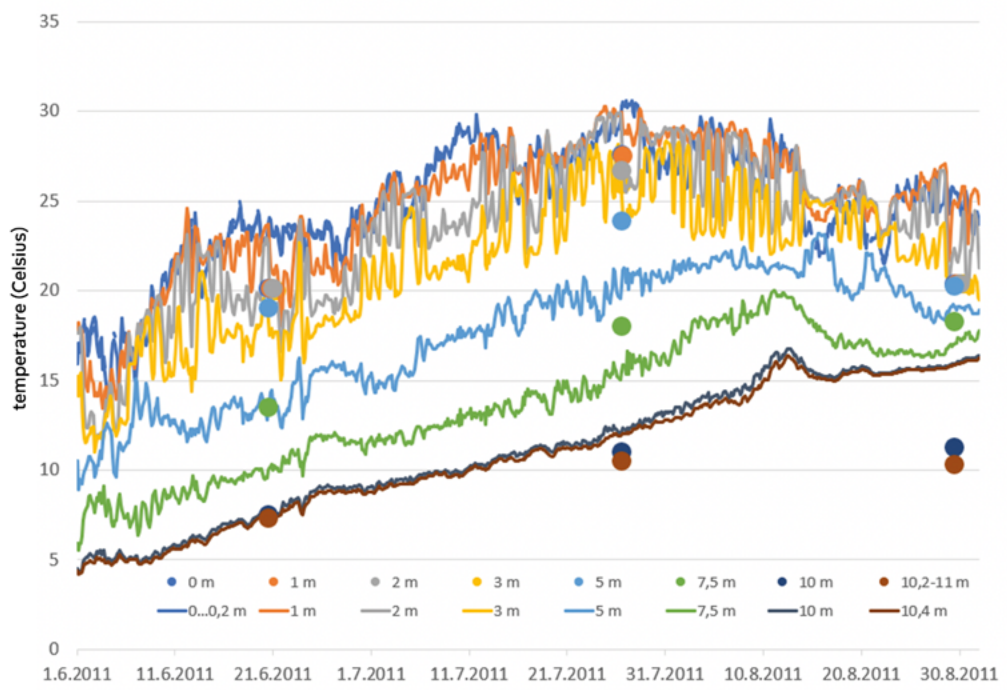


Figure 4-3. Manually observed (circles) and modelled (graphs) water temperatures at point 8 in Hästholmsfjärden.

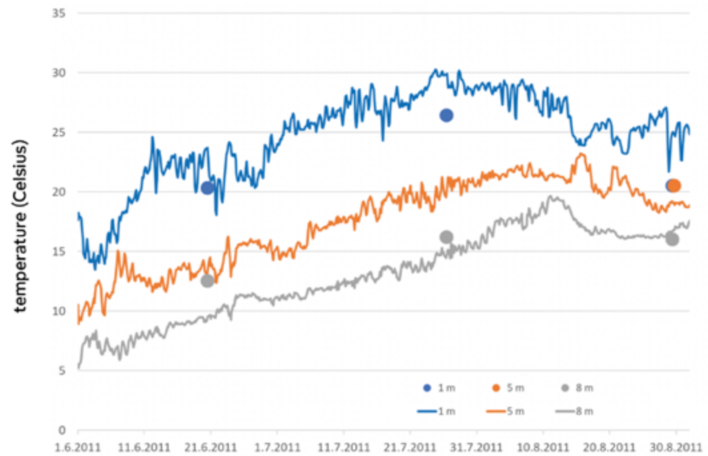


Figure 4-4. Manually observed (circles) and modelled (graphs) water temperatures at point 9 in Hästholmsfjärden.

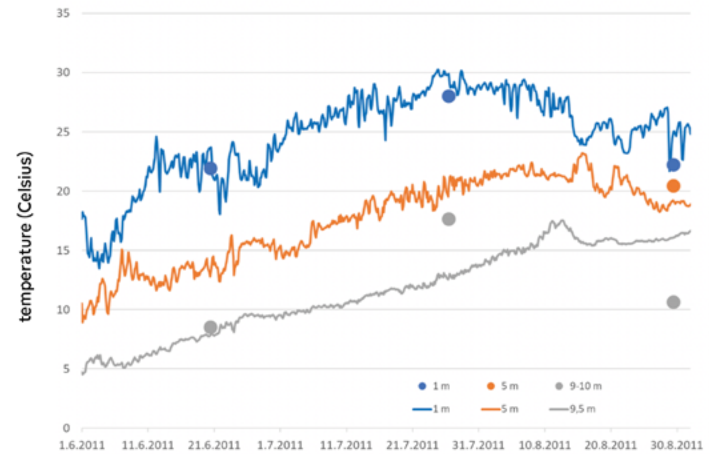


Figure 4-5. Manually observed (circles) and modelled (graphs) water temperatures at point 11 in Hästholmsfjärden.

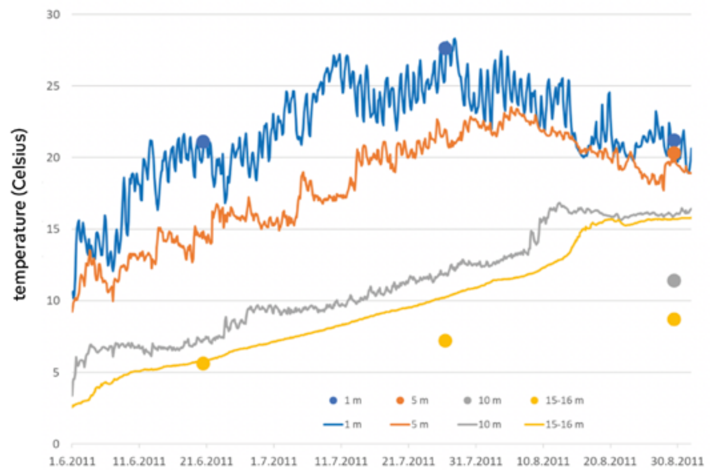


Figure 4-6. Manually observed (circles) and modelled (graphs) water temperatures at point 12 in Hästholmsfjärden.

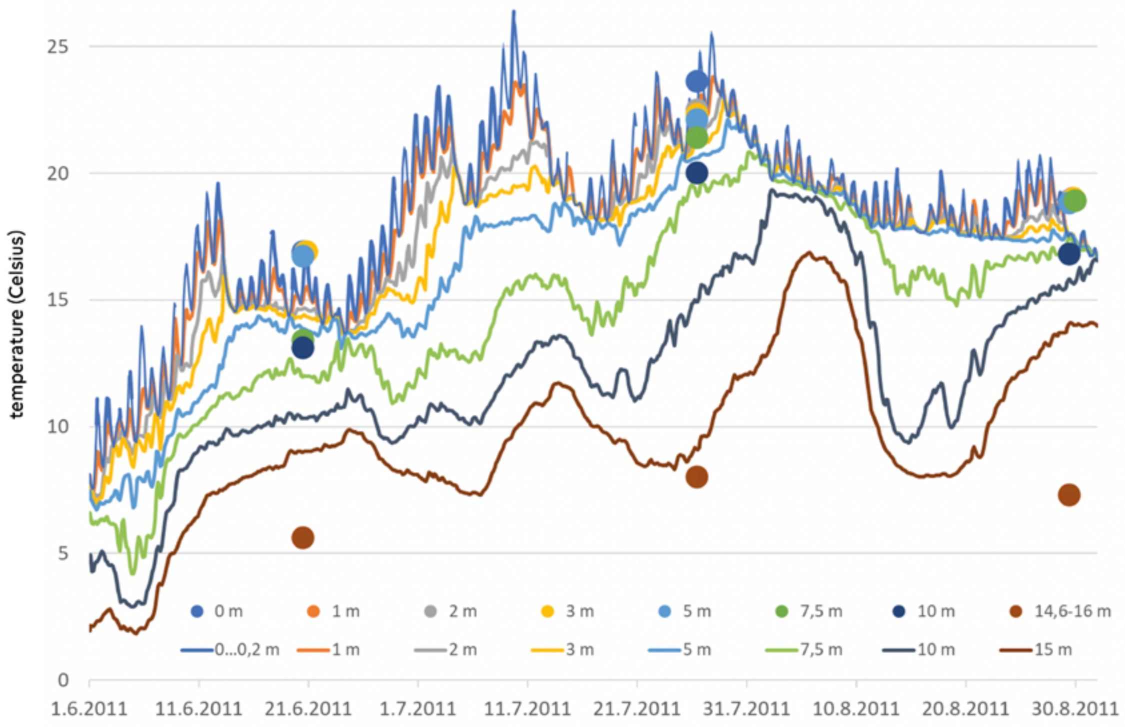


Figure 4-7. Manually observed (circles) and modelled (graphs) water temperatures at point 3 in Hudöfjärden.

modelled seawater temperatures follow the observed temperatures quite closely at points 9, 11 and 12 on the side of Hästholmsfjärden all the way down to a depth of 7.5 metres throughout the summer (Figures 4-3...4-6). The temperature modelled for deeper areas also corresponds with the observed temperature in June and July, but by the end of August, the water in the model has warmed more than the observations indicate. The temperature modelled at point 8 is higher at the surface and lower in the intermediate layer. The temperature modelled at the seabed matches the observations made in June and July, but warms more towards the end of August.

The modelled seawater temperatures therefore correspond with the observed temperatures fairly well, with the exception of the observations made at the deepest points in late August. What is key in terms of this review is that modelled temperatures close to the surface correspond with the observations. The equivalence is very adequate for reviewing the effects of the cooling water.

The seawater temperatures modelled at Hudöfjärden (Figure 4-2, point 3) correspond with the observations quite well down to a depth of 7.5 m (Figure 4-7). The temperatures modelled at a depth of 10 m and a depth of 15 m are slightly colder and warmer respectively than the observed temperatures (Figure 4-7).

4.4.2 Comparison with automated observations

The modelled seawater temperatures were also compared with the results of automatically registered measurements. The readings of the automated observations at point K1–K2 (Figure 3-1) are usually slightly lower than manually observed readings. In terms of the conditions in the summer of 2011, the seawater temperatures calculated with the model were compared with the observed seawater temperatures on the cooling water's discharge side at Hästholmsfjärden (buoys B and C), intake side at Hudöfjärden (K1) and towards the open sea at Vådholmsfjärden (K2). The comparison is shown in Figures 4-8...4-10. As can be seen from the figures, the water

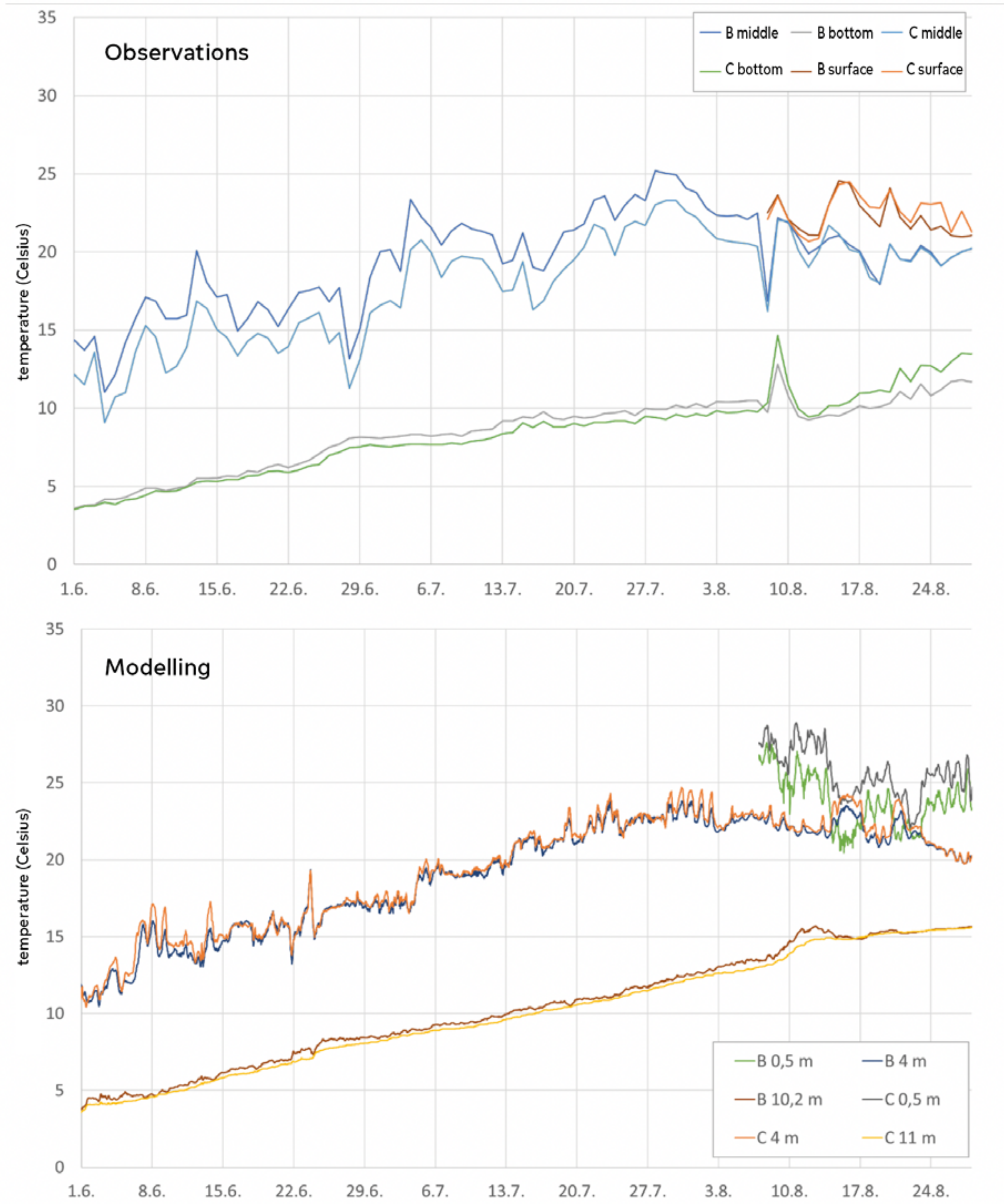


Figure 4-8. Hästholmsfjärden, buoys B and C, the observed (above) and modelled (below) water temperature at various depths in June – August 2011. The fluctuation in the observations at the beginning of August is due to the maintenance of the measuring transducer.

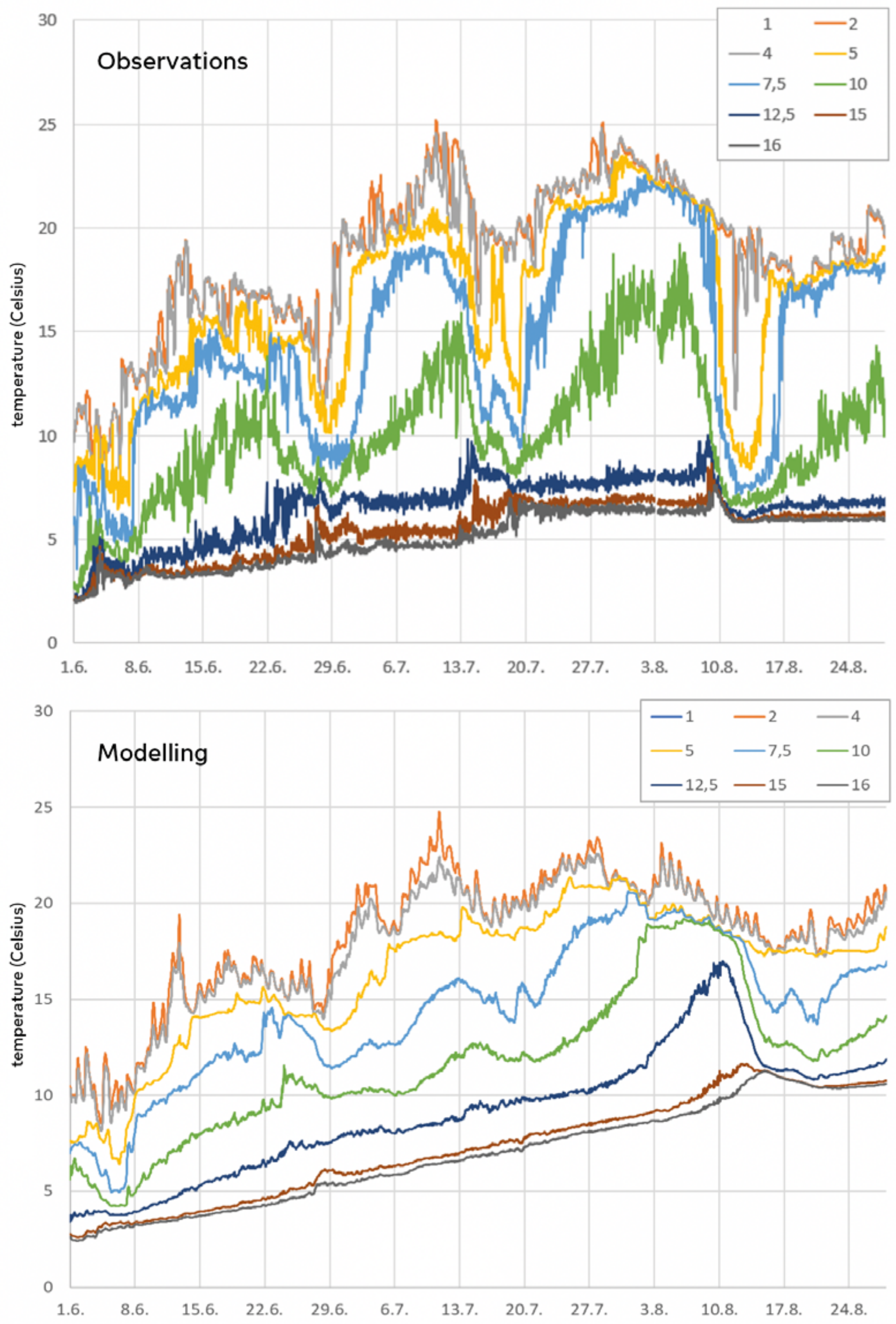


Figure 4-9. Hudöfjärden, buoy D (depths 2–4 m), point K1 (depths 5–16 m), the observed (above) and modelled (below) water temperature at various depths in June – August 2011.

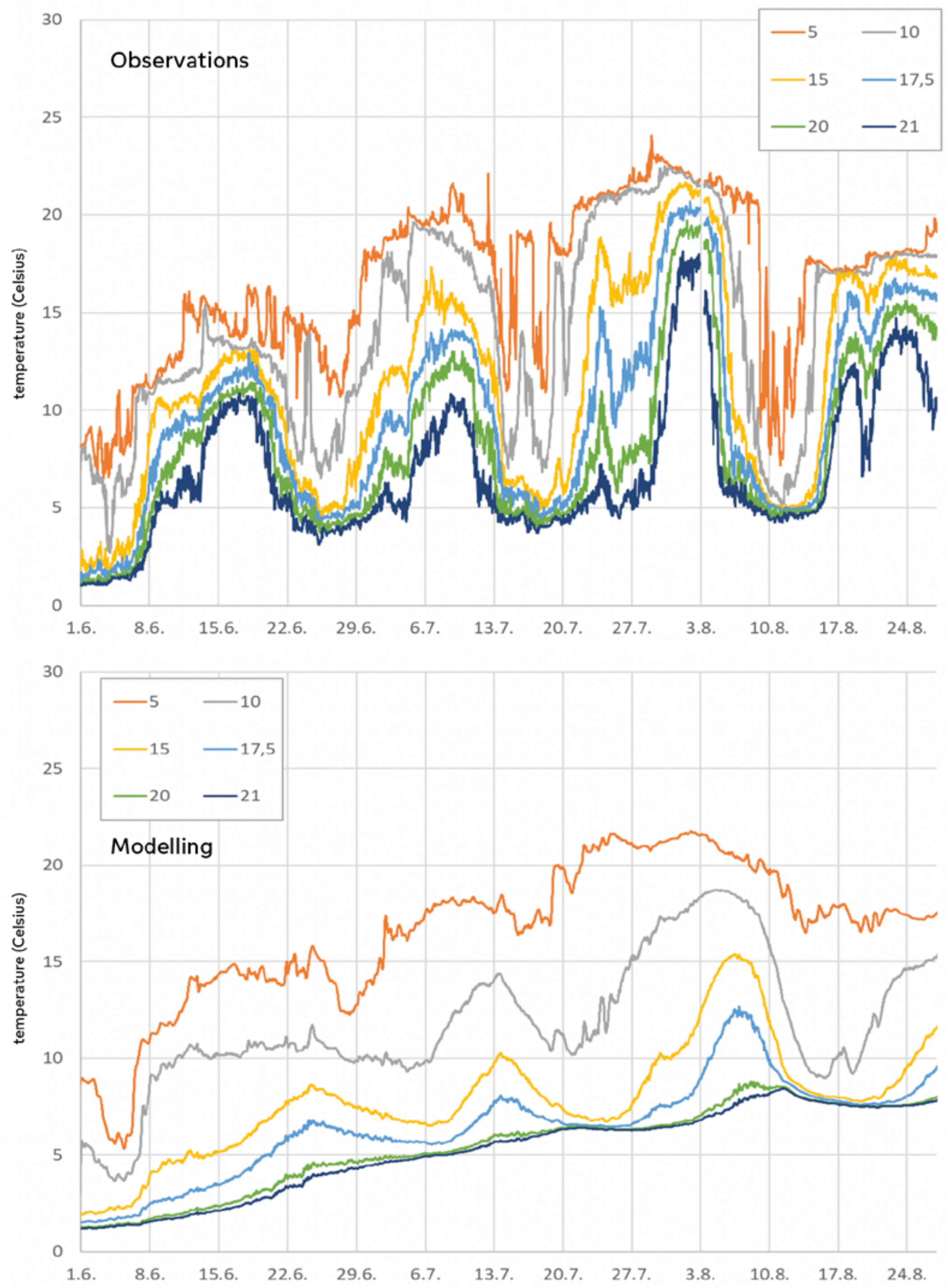


Figure 4-10. Vådholmsfjärden, point K2, the observed (above) and modelled (below) water temperature at various depths in June – August 2011.

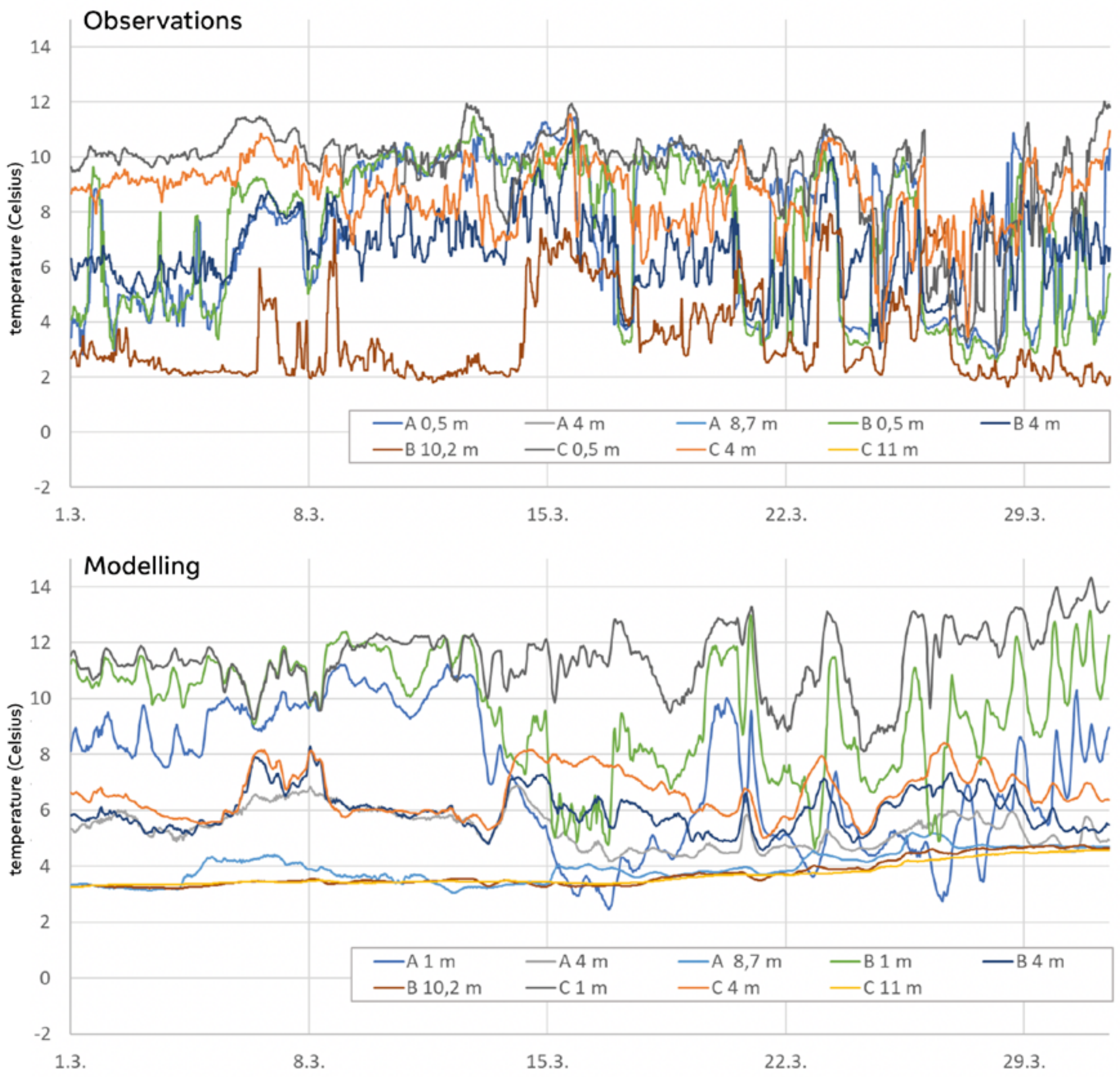


Figure 4-11. The observed and modelled water temperature at various depths and buoys A, B and C of the discharge side in Hästholmsfjärden (Figure 3-3) in March 2018.

temperatures modelled in Hästholmfjärden – important in terms of the effects of the warm cooling water – follow the observed temperatures fairly well. The winter comparison is shown in Figure 4-11.

Further from Hästholmen, in Hudöfjärden and Vådholmsfjärden, the model describes the upwelling and downwelling events as smoother than the events observed. Based on the observations, the strong upwelling situation which began in early August occurs slightly later in the modelling and remains significantly lower in strength than the observed upwelling. In the modelling results of Hästholmsfjärden and Hudöfjärden, the temperatures of the deeper water increase more towards the end of August than in the observations.

In respect of Vådholmsfjärden, the modelled temperatures of the deeper water are lower than those observed. The temperature of the seawater modelled close to the surface nevertheless follows the observed temperature fairly closely. Particularly with regard to Hästholmsfjärden, the modelled surface temperatures correspond with the observations quite well.

4.5 UNCERTAINTIES RELATED TO MODELLING

All modelling involves uncertainties and is never a perfect representation of reality. The errors in the outcomes of the modelling stem from the uncertainties of the baseline data and boundary conditions as well as from the model's parametrisations and numerical calculations. The open sea's sea level used as baseline data, for example, was assessed with the help of the sea levels of Helsinki and Hamina, meaning that the assessment is not fully accurate. On the other hand, the assessment is nevertheless sufficiently good from the perspective of the cooling water modelling and as a source of error, is not that significant. In respect of sources of error, it is indeed essential to identify the most important of them and seek to improve the situation in terms of them insofar as is possible and necessary.

The most relevant sources of error in the modelling carried out in this work are the model's heat transfer from the surface water into the atmosphere, which was calculated, in terms of the longwave radiation, by employing infrared radiation values observed in Kumpula, Helsinki, rather than the surface water temperature. In principle, this feature slows down the transfer of heat from water into air, increasing the water temperature more than it increases in reality. However, this challenge was dealt with satisfactorily by calibrating the model on the basis of the measurements so that the surface temperatures assessed by it corresponded well with the measurements. The realistic description of surface temperatures is the key objective in terms of the results of this work.

Another source of error with a potentially significant effect on the results is the model's success in describing the water's vertical mixing. This is influenced particularly by the selections of the numerical values for the parameters that determine the mixing and the structure of the model's calculation grid. The realism of the vertical mixing was a particular focus in connection with the model's calibration.

The water in the Baltic Sea is brackish water, meaning that its salinity ranges from 0.5%–24.7‰. The salinity in the coastal waters of the Gulf of Finland is typically less than 5‰, but there is some variation in the salinity. The physical properties of brackish water make it a difficult substance from the perspective of the modelling, thereby further increasing the significance of the calibration of the model based on the measurements. The characteristics of the Gulf of Finland also include upwelling and downwelling situations which have a significant impact on the seawater's temperature and salinity conditions, and the description of which by modelling is a challenging task.

5. Modelling results

5.1 ICE-FREE SEASON

Figures 5-1...5-4 show the differences in seawater temperatures between situations in which the power plant is in operation or is not in operation, modelled under ice-free conditions. The time series of the modelling results of seawater temperature at different receiver points and in different situations (power plant in operation or not in operation) are presented in Appendix 2. The reviews are presented at the points of the buoys on the discharge side, K1, K2 and K3 (Figures 3-1 and 3-3). Figures 5-5...5-7 show maps on the average, minimum and maximum temperature.

At the locations of buoys A, B and C, close to the cooling water's discharge location in Hästholmsfjärden, the surface temperature of seawater during the power plant's operation is 1–11 °C warmer than in situations when the power plant is not in operation (Figure 5-1). The temperature differences between the different situations were greatest at the locations of buoys B and C, whereas there is significantly less variation at buoy A. The differences between the locations are explained by the fact that during the power plant's operation, buoys B and C are more distinctly within the cooling water's impact area, while buoy A is slightly further away from it. The relatively large range of variation in seawater surface temperatures at an individual location (such as buoy B and a review depth of 0.5 m) is largely explained by changes in wind conditions, given that changes in wind direction change the route of warm cooling water, sometimes past the observation point and at other times towards it. The increase in the deep's temperature at the locations of buoys A, B and C grows over the summer and is around 2–3 °C in August.

Based on maps drawn up on the basis of the modelling results (Figures 5-5...5-7), the greatest increase in the seawater's surface temperature caused by the power plant occurs right next to the discharge location in Hästholmsfjärden. However, the surface temperature rapidly drops when moving further, given that the surface water is mixed in with the rest of the water column horizontally and vertically, and heat is also transferred efficiently into the atmosphere. The average surface temperature increases by roughly 2 °C in southern Hästholmsfjärden. In western and northern Hästholmsfjärden, the estimated impact no longer exceeds parts of a degree due to the slow flow of water into these areas. Based on the modelling results, surface water temperature can nevertheless occasionally rise in some of these areas due to the thermal effect of the cooling water, with the maximum increase being 2 °C.

Based on the cross-sectional views (Figures 5-5...5-7), one can estimate that the effect that the power plant's operation has on the temperature of seawater during the ice-free season is primarily confined to the top 5 m layer in the southern part of Hästholmsfjärden. Calculated for the Klobbfjärden body of water (Hästholmsfjärden + Klobbfjärden), the estimated average increase in surface temperature is around 1.12 °C. The surface area of the shallow areas further away from the power plant is slightly smaller in the model than in reality, which must be accounted for in the interpretation of the results.

Based on the modelling, the average seawater temperature close to the surface on the discharge side at point K1 in Hudöfjärden is approximately 0.1–0.9 °C higher during the power plant's operation than without the power plant (Figure 5-2). The thermal effect on the Hudöfjärden side is minor and usually detectable only in the far northeast corner near Hästholmen

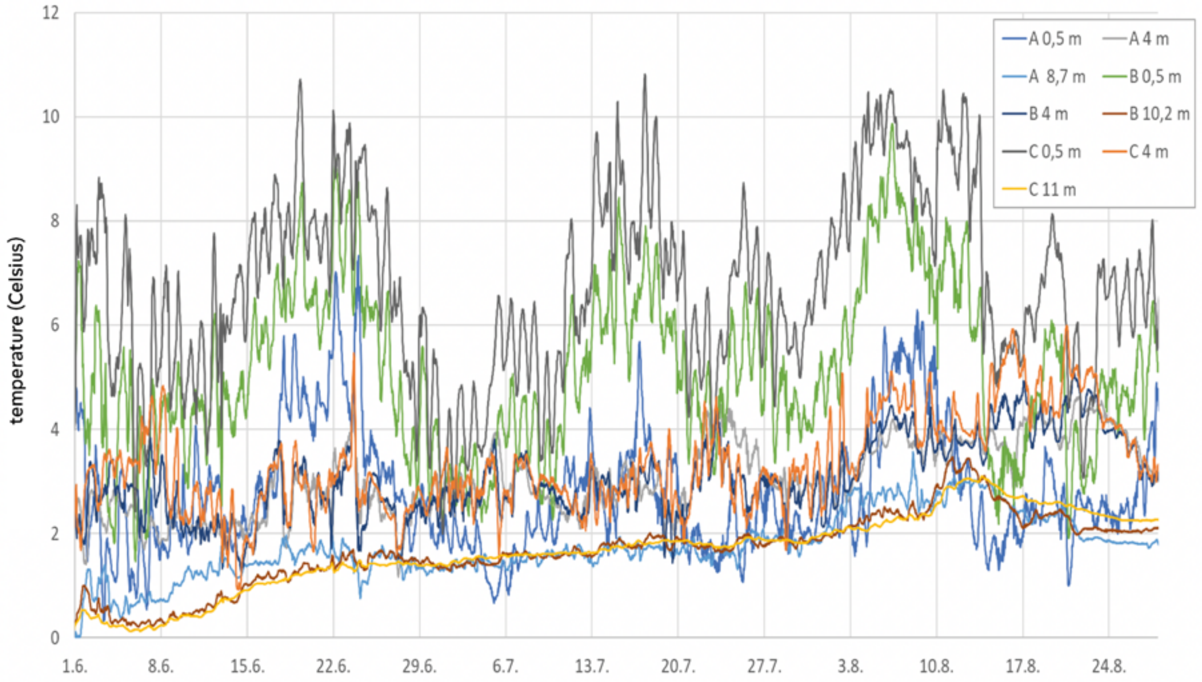


Figure 5-1. The difference in water temperature modelled at different depths (power plant in operation – power plant not in operation) in Hästholmsfjärden on the discharge side's buoys A, B and C during the 2011 ice-free season.

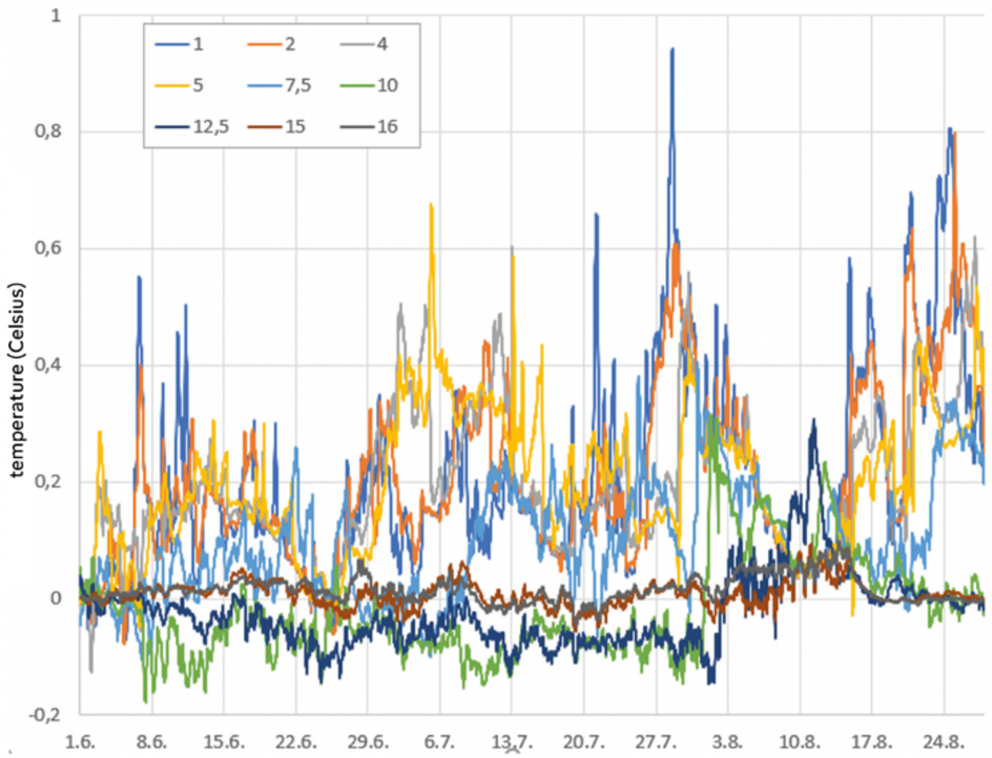


Figure 5-2. The difference in water temperature modelled at different depths (power plant in operation – power plant not in operation) in Hudöfjärden at point K1 during the 2011 ice-free season.

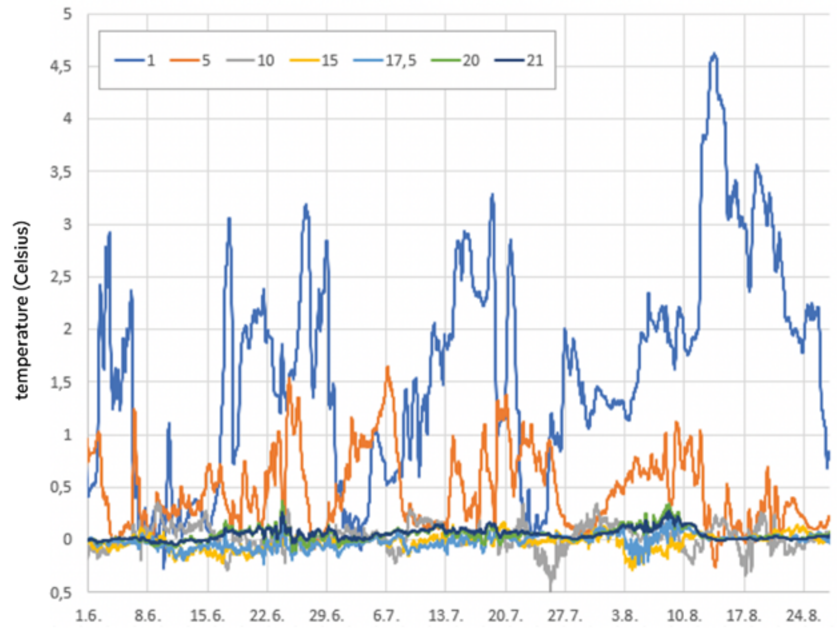


Figure 5-3. The difference in water temperature modelled at different depths (power plant in operation – power plant not in operation) in Vådholmsfjärden at point K2 during the 2011 ice-free season.

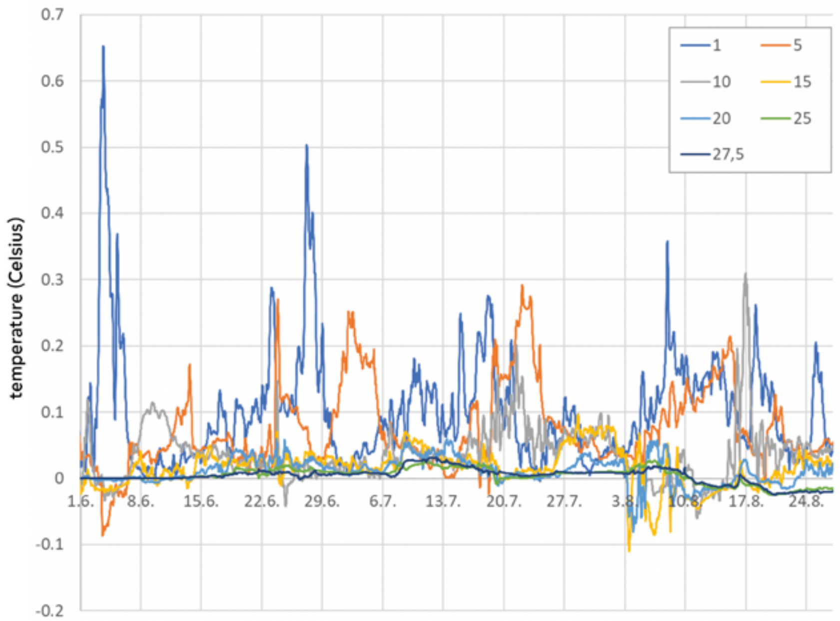


Figure 5-4. The difference in water temperature modelled at different depths (power plant in operation – power plant decommissioned) in Orrengrundsfjärden at point K3 during the 2011 ice-free season.

(Figures 5-5...5-7). However, under some weather conditions, the surface temperature can occasionally rise by a maximum of 2 °C in the parts of Hudöfjärden close to Hästholmen.

At observation point K2, located in front of the straits leading from Hästholmsfjärden to Vådholmsfjärden, a thermal effect occurs at the very surface of the sea, according to the modelling results. Based on the results, the temperature of the seawater during the power plant's operation is roughly 0–4.5 °C warmer at a depth of one metre and 0–1.5 °C warmer at a depth of five metres than it would if the power plant were decommissioned (Figure 5-3). Deeper still, at 10 metres, no temperature increase can be detected. Based on maps prepared on the basis of the modelling results, the effect is at its greatest in Vådholmsfjärden near the mouth of the strait between the islands of Myssholmen and Lindholmen, where the water temperature at the surface can occasionally increase by a maximum of approximately 5 °C. In the southern part of Vådholmsfjärden, the temperature increase is estimated to be around 1 °C at maximum (Figures 5-5...5-7). The average increase in surface temperature in the northern parts of Vådholmsfjärden is in the region of 2 °C. The temperature difference nevertheless diminishes when moving south so that as early as in the mid-sections of Vådholmsfjärden, the thermal effect that the power plant's operation has on the average surface temperature of the seawater is difficult to detect.

At observation point K3 in Orrengrundsfjärden, the thermal effect on the surface layer is very small (Figure 5-4). In a small area in the northwestern part of Orrengrundsfjärden, the effect is close to 0.5 °C, the maximum being approximately 1.5 °C at the part leading to Vådholmsfjärden.

Based on the modelling, a thermal effect caused by the power plant during the ice-free season is mainly detectable in Hästholmsfjärden and occasionally on the surface of the straits south of it.

The 2011 ice-free season reviewed represents an exceptionally warm summer in the conditions of the 2010s. The year selected for review was 2011, primarily because of the extensive additional monitoring of seawater temperatures conducted during the year, which allows for a more precise calibration of the cooling water model. On the other hand, the selection of an exceptionally warm year provides a per-

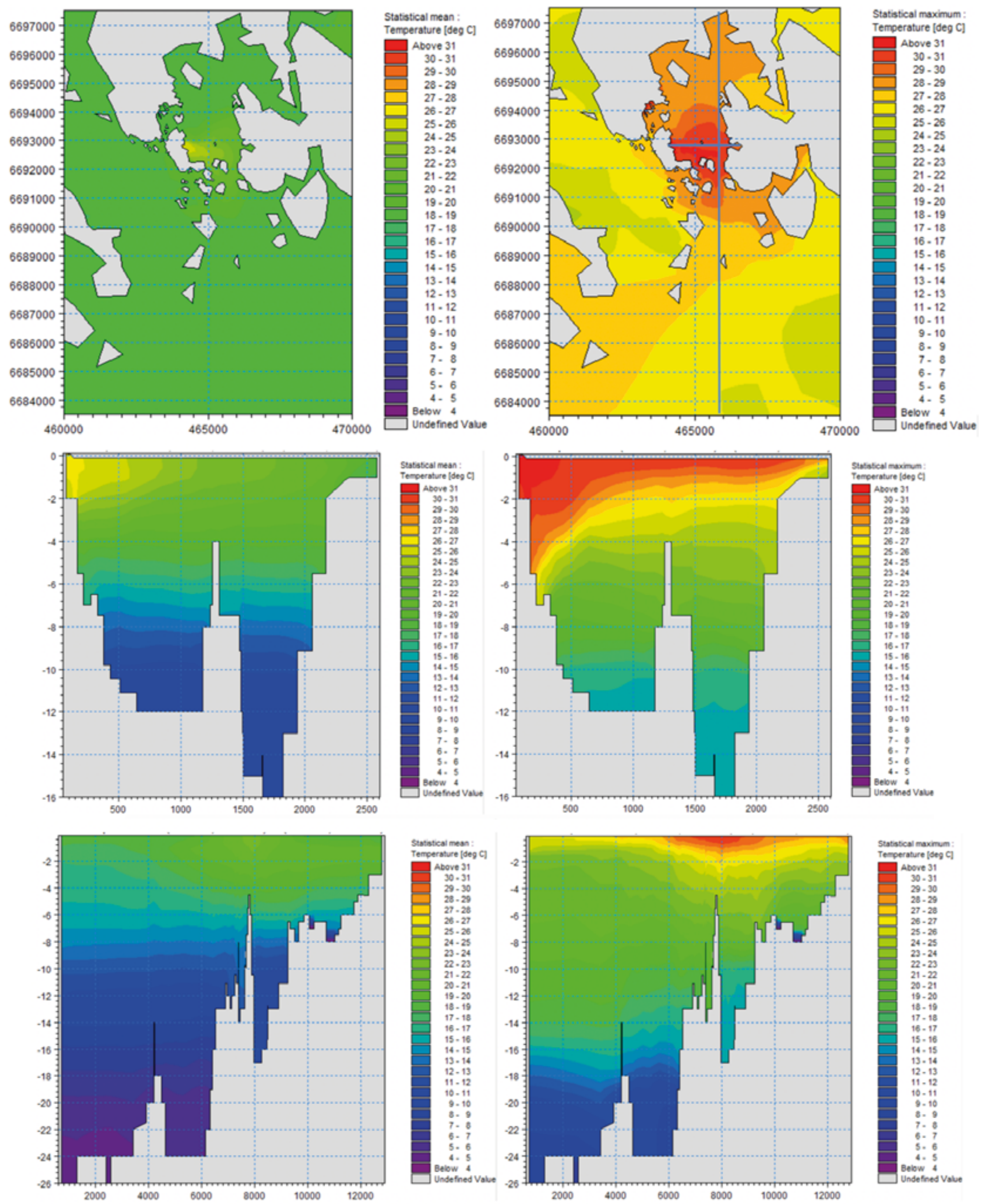


Figure 5-5. Temperature, power plant in operation, average (column on the left) and maximum (column on the right); map (top row), east-west cross section form the intake (in the middle, left boundary westward) and north-south cross section (bottom row, left boundary southward), period 1 June – 1 September 2011. The lines of the cross-sectional views are shown in the map image of maximum temperatures. The coordinate system in the map images is ETRS-TM35FIN. In the other figures, the distance (horizontal axis) and depth (vertical axis) is indicated in metres.

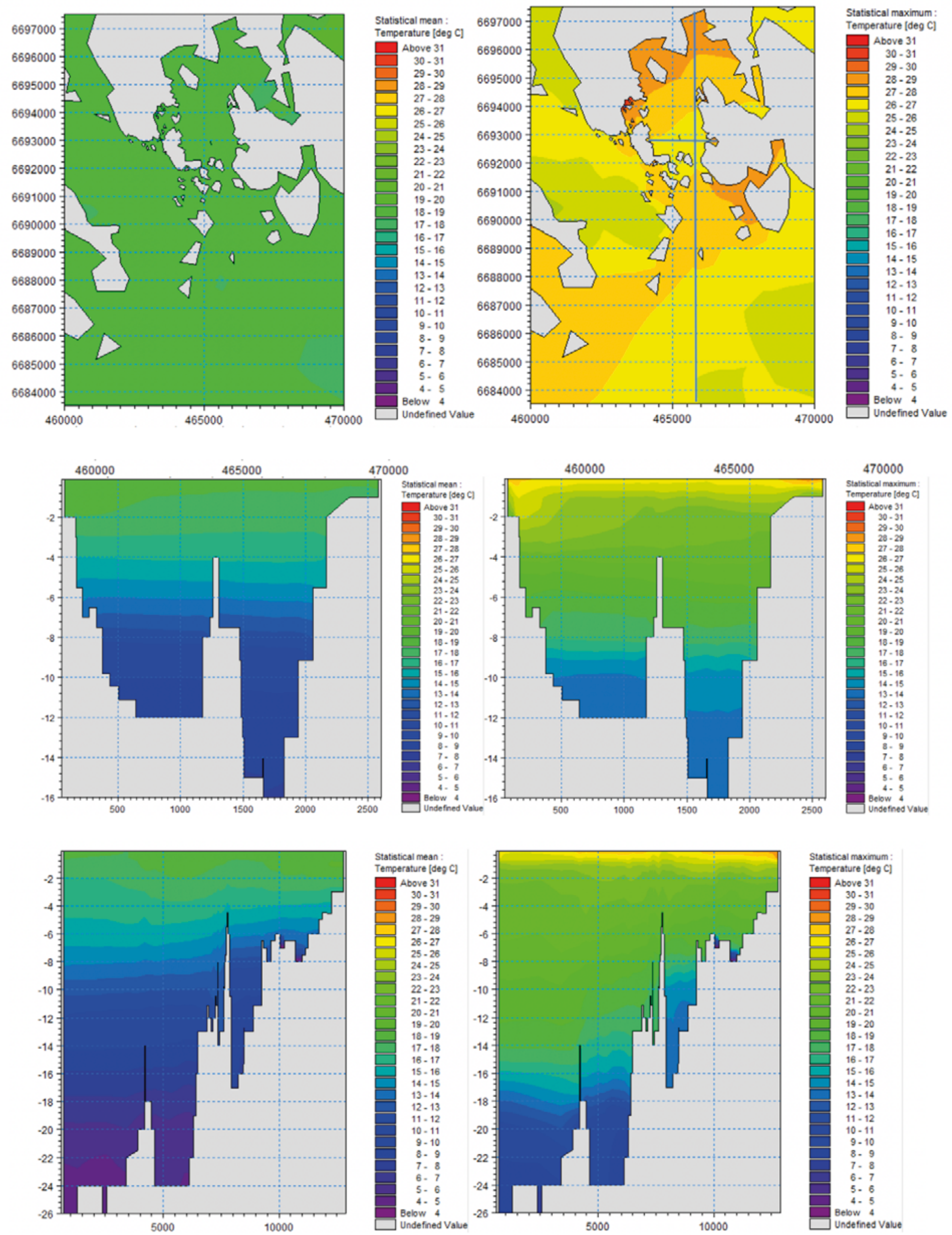


Figure 5-6. Temperature, power plant not in operation, average (column on the left) and maximum (column on the right); map (top row), east-west cross section form the intake (in the middle, left boundary westward) and north-south cross section (bottom row, left boundary southward), period 1 June – 1 September 2011. The lines of the cross-sectional views are shown in the map image of maximum temperatures. The coordinate system in the map images is ETRS-TM-35FIN. In the other figures, the distance (horizontal axis) and depth (vertical axis) is indicated in metres.

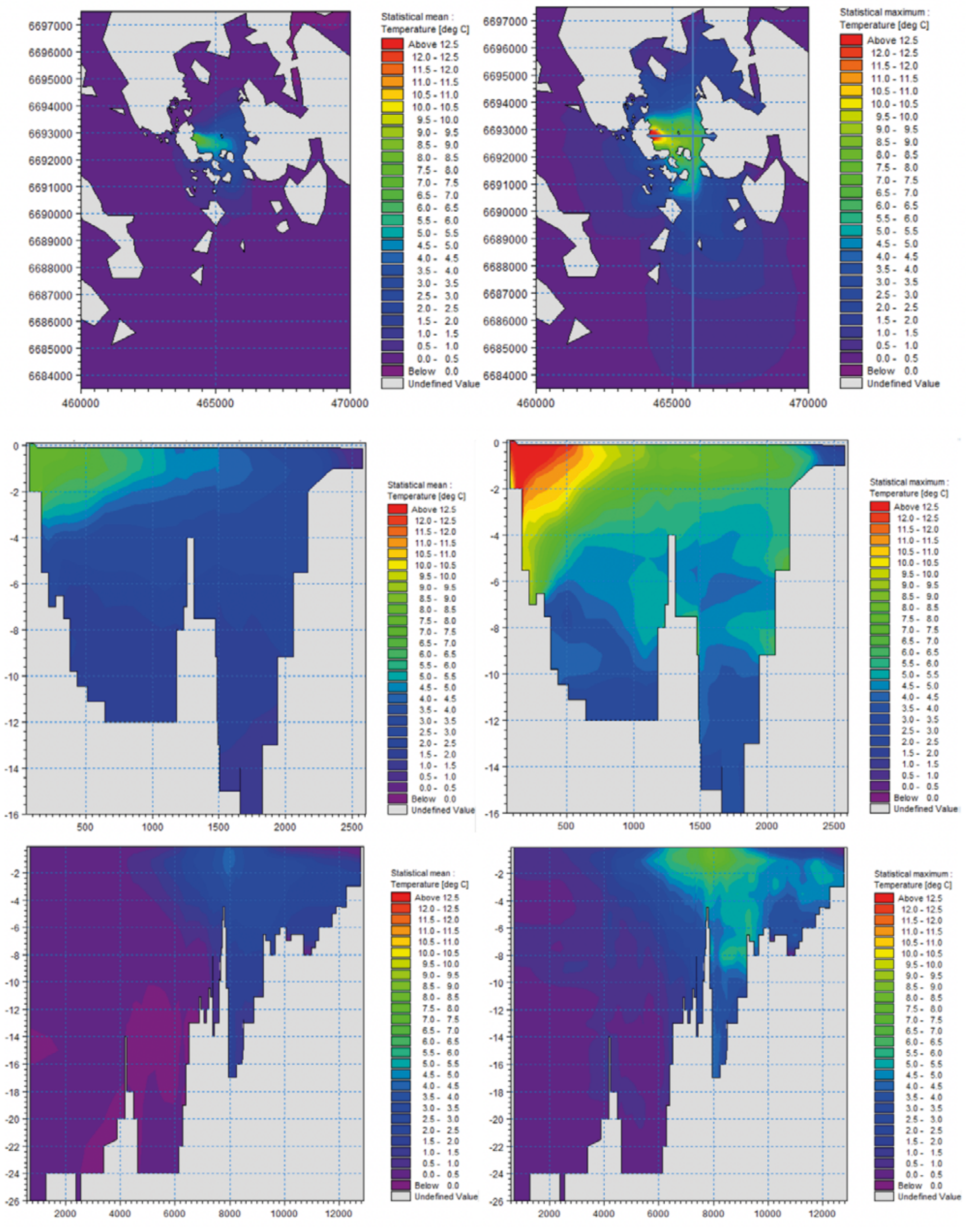


Figure 5-7. Effect of power plant's operation on temperature (difference: power plant in operation – power plant not in operation), average (column on the left) and maximum (column on the right); map (top row), east-west cross section form the intake (in the middle, left boundary westward) and north-south cross section (bottom row, left boundary southward), period 1 June – 1 September 2011. The lines of the cross-sectional views are shown in the map image of maximum temperatures. The coordinate system in the map images is ETRS-TM35FIN. In the other figures, the distance (horizontal axis) and depth (vertical axis) is indicated in metres.

spective to the development of the temperature conditions of seawater in the future, as the climate grows warmer. As explained in Chapter 3.3, the summer temperatures in 2011 are likely to be fairly ordinary in the climate conditions of 2030–2050 or at least significantly more common than at the beginning of the 2010s. The modelling results of the review period therefore give an idea of seawater temperatures around the middle of this century in a situation where the power plant is in operation, and in a situation where it is not in operation. The absolute temperatures with regard to the ice-free season are specified in Appendix 2.

When examining the results at the temperature measuring buoys on Hästholmsfjärden's discharge side (Figures L2-1 and L2-2 in Appendix 2), for example, one can see that the surface temperature of the seawater during the power plant's operation is at its highest, or slightly above 30 °C, at buoy C, whereas the surface temperature at the same point and same time in a situation in which the power plant is not in operation is around 25 °C. According to Loviisa power plant's environmental permit, the hourly average temperature of the cooling water fed into the sea may be a maximum of 34 °C. In other words, when the temperature of the cooling water taken from the sea rises to a degree where the power plant's power must be limited for the temperature of the discharged cooling water to remain below 34 °C, the relative share of the power plant's thermal effect will also reduce. When moving away from Hästholmsfjärden, the temperature differences in the seawater are fairly small and at their highest, in the region of 20–25 °C (Figures L2-3...L2-8 in Appendix 2).

5.2 ICE SEASON

Figures 5-8...5-11 show the differences in seawater temperatures between situations in which the power plant is in operation or is not in operation, modelled under ice-cover conditions. The time series of the modelling results of seawater temperature at different receiver points and in different situations (power plant in operation or not in operation) are presented in Appendix 3. The reviews are presented at the points of the buoys on the discharge side, K1, K2 and K3 (Figures 3-1 and 3-3). Figures 5-12...5-14 show maps of the average and maximum temperature in situations where the power plant is in operation and is not in operation as well as the difference between them.

When the power plant is in operation, the seawater temperature at buoys A, B and C, located close to the discharge location of cooling water in Hästholmsfjärden, is approximately 5–16 °C and approximately 5–9 °C at depths of 1m and 4 m, respectively, and close to the seabed, approximately 3–5 °C higher than in a situation where the power plant is not in operation (Figure 5-8).

A temperature increase of 0–3 °C attributable to the recirculation of warm cooling water can be detected at point K1 on the side of Hudöfjärden when the power plant is in operation. This increase is primarily confined to a depth of 4–5 m (Figure L3-3 in Appendix 3). In a situation where the power plant is not in operation, the seawater temperature remains even throughout the water body (Figure L3-4 in Appendix 3). Figure 5-9 illustrates the warming of seawater attributable to recirculation.

At observation point K2 in front of the straits leading from Hästholmsfjärden to Vådholmsfjärden, the thermal effect is visible to a varying degree at all depths. The difference in temperature in a situation where the power plant is in operation vis-à-vis a situation where it is not operation is at its greatest approximately 5 °C higher at a depth of 5 m (Figure 5-10). Nevertheless, the thermal effect seems to be situated primarily at a depth of 5 m and deeper than that, being at its smallest near the surface.

The thermal effect is very small at Orrengrundsfjärden's observation point K3. The seawater temperature is only around 0–0.8 °C higher during the power plant's operation than in a situation where the power plant is no longer in operation (Figure 5-11). As is the case with point K2, the thermal effect at this observation point also concentrates at a depth below 5 m.

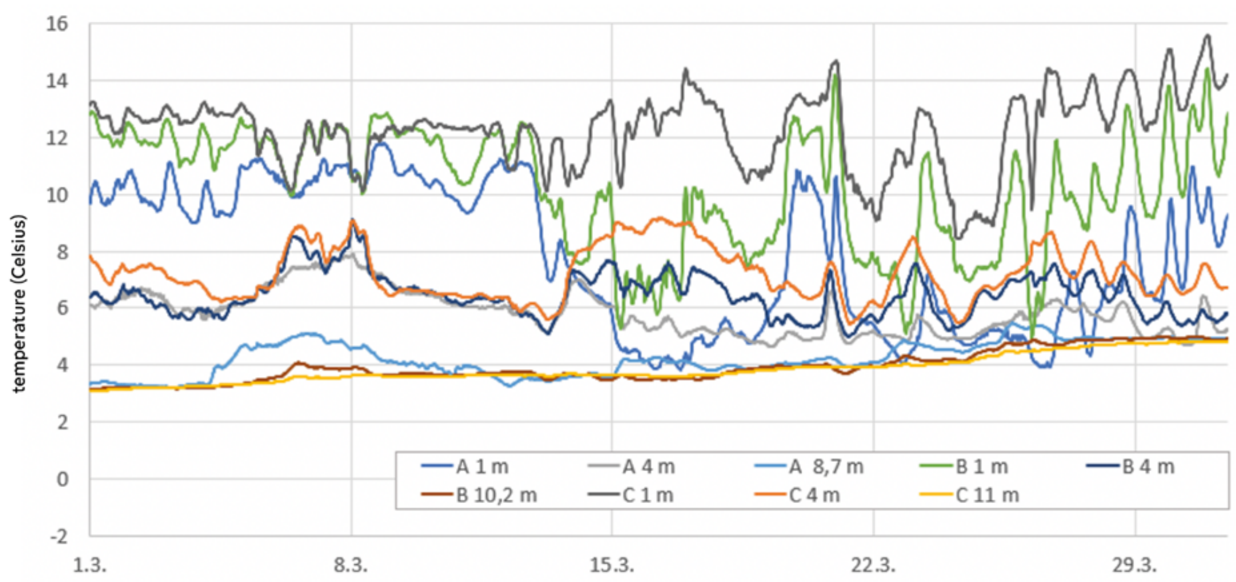


Figure 5-8. The difference in water temperature modelled at different depths (power plant in operation – power plant not in operation) in Hästholmsfjärden on the discharge side's buoys A, B and C in March 2018.

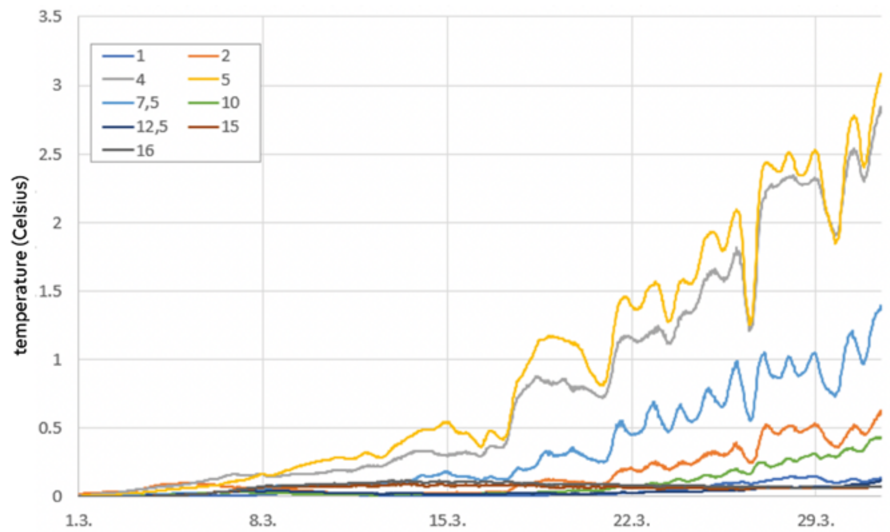


Figure 5-9. The difference in water temperature modelled at different depths (power plant in operation – power plant decommissioned) in Hudöfjärden at point K1 in March 2018.

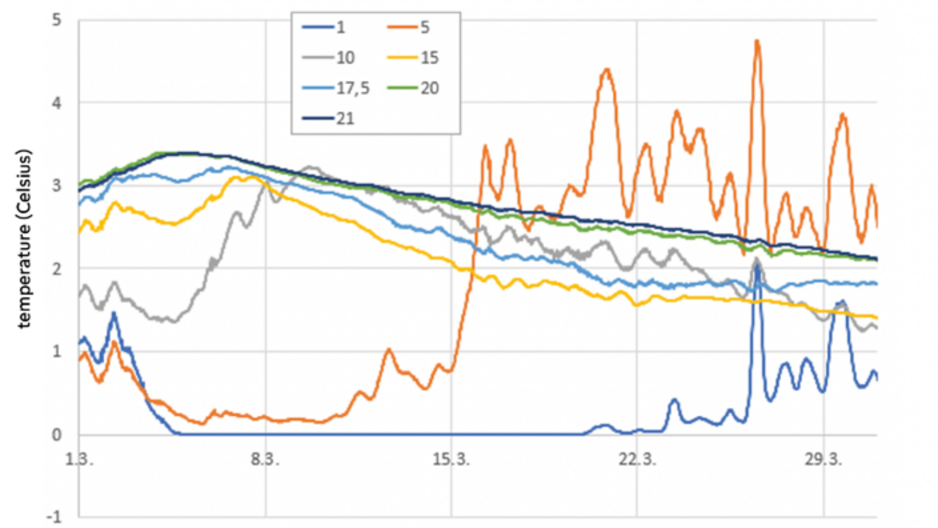


Figure 5-10. The difference in water temperature modelled at different depths (power plant in operation – power plant decommissioned) in Vådholmsfjärden at point K2 in March 2018.

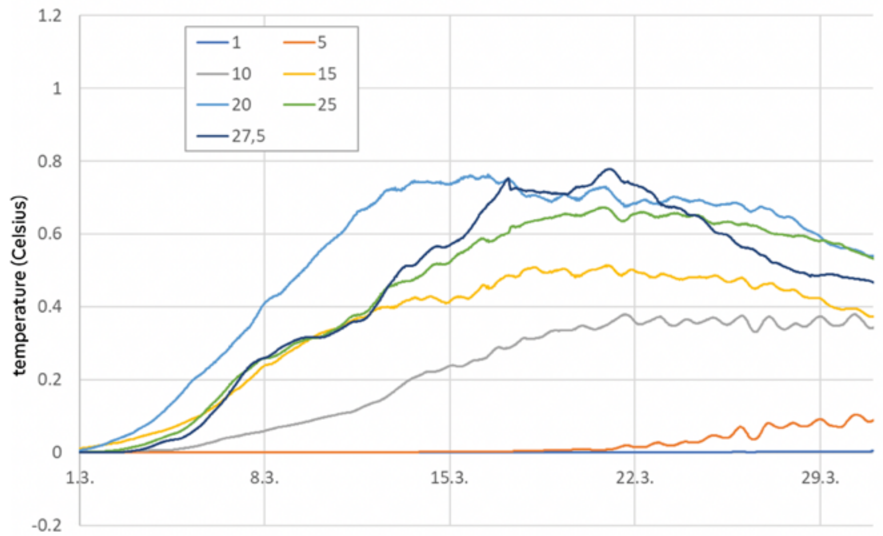


Figure 5-11. The difference in water temperature modelled at different depths (power plant in operation – power plant decommissioned) in Orrengrundsfjärden at point K3 in March 2018.

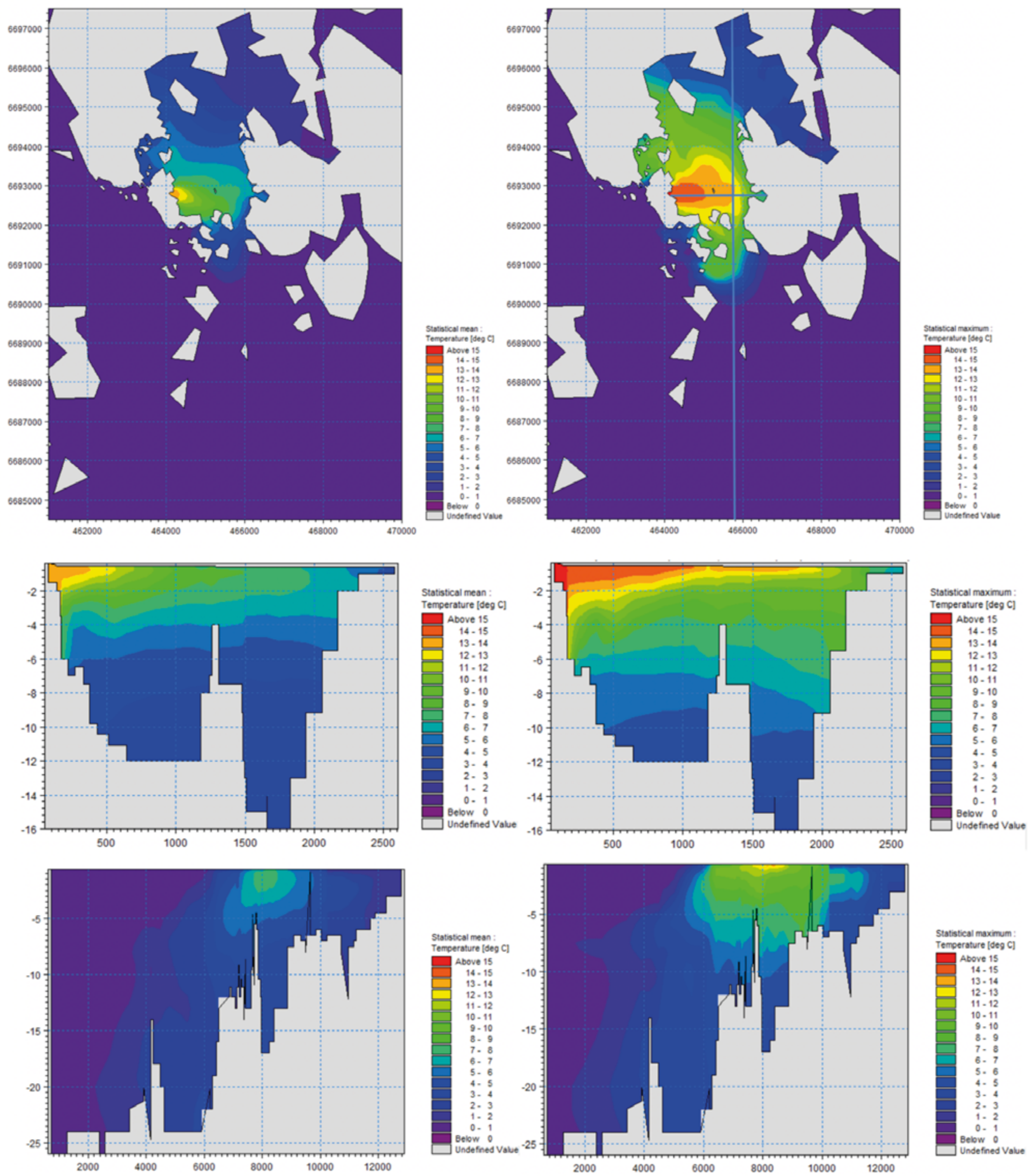


Figure 5-12. Temperature, power plant in operation, average (column on the left) and maximum (column on the right); map (top row), east-west cross section from the intake (in the middle) and north-south cross section (bottom row), period March 2018. The lines of the cross-sectional views are shown in the map image of maximum temperatures. The coordinate system in the map images is ETRS-TM35FIN. In the other figures, the distance (horizontal axis) and depth (vertical axis) is indicated in metres.

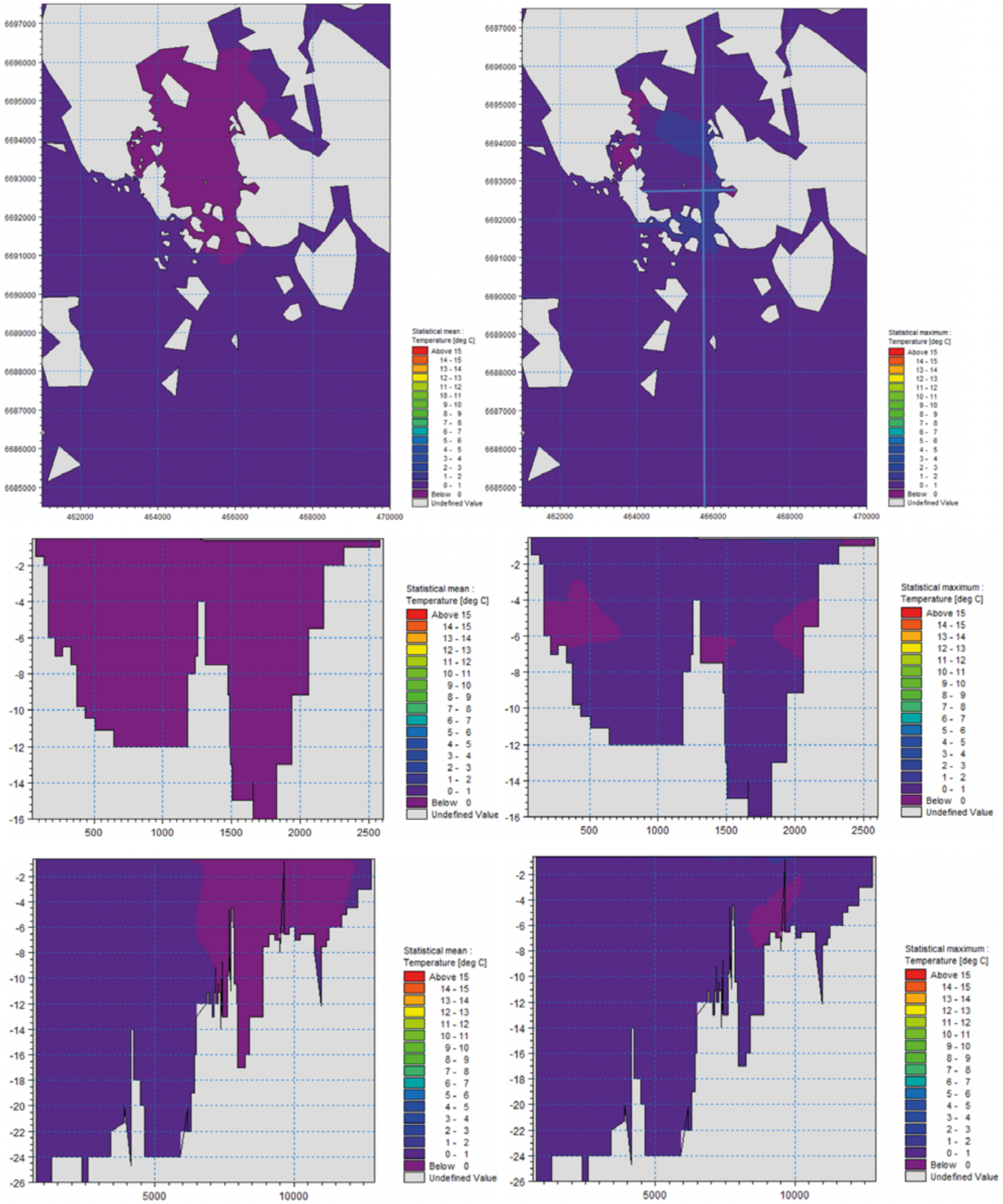


Figure 5-13. Temperature, power plant not in operation, average (column on the left) and maximum (column on the right); map (top row), east-west cross section from the intake (in the middle) and north-south cross section (bottom row), period March 2018. The lines of the cross-sectional views are shown in the map image of maximum temperatures. The coordinate system in the map images is ETRS-TM35FIN. In the other figures, the distance (horizontal axis) and depth (vertical axis) is indicated in metres.

The thermal load's impact on the nearby sea area is the easiest to detect in winter, when the warm cooling water keeps the sea area close to the discharge location free of ice. The ice cover is effective in preventing the heat from transferring to the atmosphere once the cooling water has sunk more deeply and passed beneath the ice. During the ice season, the greatest thermal effect is detectable near the surface particularly in the southern part of Hästholmsfjärden, but also on a wider scale in the area of Hästholmsfjärden. At Vådholmsfjärden, the thermal effect is still detectable near the surface, but at distances further than this, the effect extends only to the deeper water, with hardly any effect on the surface (Figures 5-12...5-14).

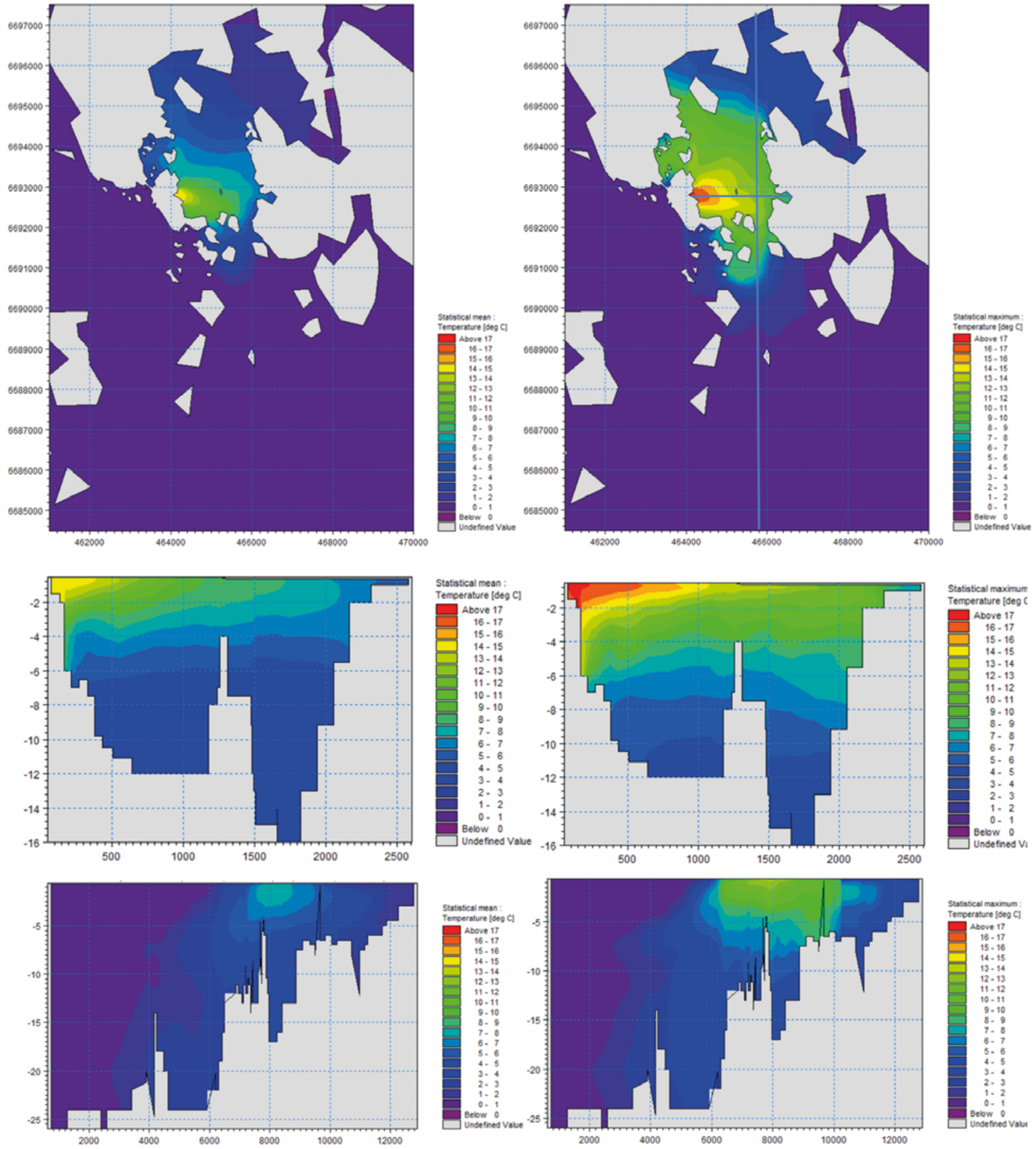


Figure 5-14. Effect of power plant's operation on temperature (difference: power plant in operation – power plant not in operation), average (column on the left) and maximum (column on the right); map (top row), east-west cross section from the intake (in the middle) and north-south cross section (bottom row), period March 2018. The lines of the cross-sectional views are shown in the map image of maximum temperatures. The coordinate system in the map images is ETRS-TM35FIN. In the other figures, the distance (horizontal axis) and depth (vertical axis) is indicated in metres.

The seawater temperatures according to the modelling in a situation where the power plant is in operation and in a situation where it is not in operation during the ice season are presented in Appendix 3. At the temperature measuring buoys on Hästholmsfjärden's discharge side, where the thermal effect of the cooling water is the greatest, surface temperatures are a maximum of 10–14 °C when the power plant is in operation. In a situation where the power plant is not in operation, the temperatures throughout the water body are -2–0 °C.

6. Comparisons

6.1 ICE-FREE SEASON

Figure 6-1 shows the results of the cooling water modelling carried out in 2008 and the cooling water modelling carried out in this work with regard to surface water temperatures in summer conditions. The environmental conditions in the 2008 modelling were described with the help of averages concerning a longer period of time, due to which the temperatures' numerical values are not entirely comparable with the modelling results of this work (Toppila 2008). Comparisons can nevertheless be made in terms of the directions in which the cooling water is carried. Based on the graphs, the dispersion of the warm cooling water in the 2008 modelling into the area of Hästholmen and Klobbfjärden is significantly stronger, but the temperatures immediately in front of the discharge location of the cooling water are significantly lower than in the modelling results in this work. The 2008 cooling water modelling was carried out with a markedly simpler model, which explains the differences between the results.

Figure 6-2 presents water temperature time series based on the cooling water modelling at Hästholmsfjärden's point 8 and Hudöfjärden's point 3 (the locations are shown in Figure 4-2) for the ice-free season. The figures on top (a and b) are the results of the modelling carried out for this work, while the figures at the bottom (c and d) are the results of a cooling water modelling carried out by an external organisation of experts in 2010 (DHI 2010). The modelled situations are from different years (2011 and 2008), due to which the results are not comparable. However, the modelling results are accompanied by the results of temperature measurements, due to which a comparison of the modelled and measured temperature allows for assessing the success of the modelling.

What can be concluded above all on the basis of Figure 6-2 is that the water body's stratification in the summer of 2011 was significantly stronger than in 2008, given that the temperature difference between the seabed and the surface was greater. The 2008 conditions were therefore more favourable from the perspective of modelling. This is also evident in the results, because the seawater temperatures modelled in 2008 are closer to the observations than the seawater temperatures modelled in 2011. Nevertheless, the modelling results of the surface temperatures in both years are fairly close to the observations.

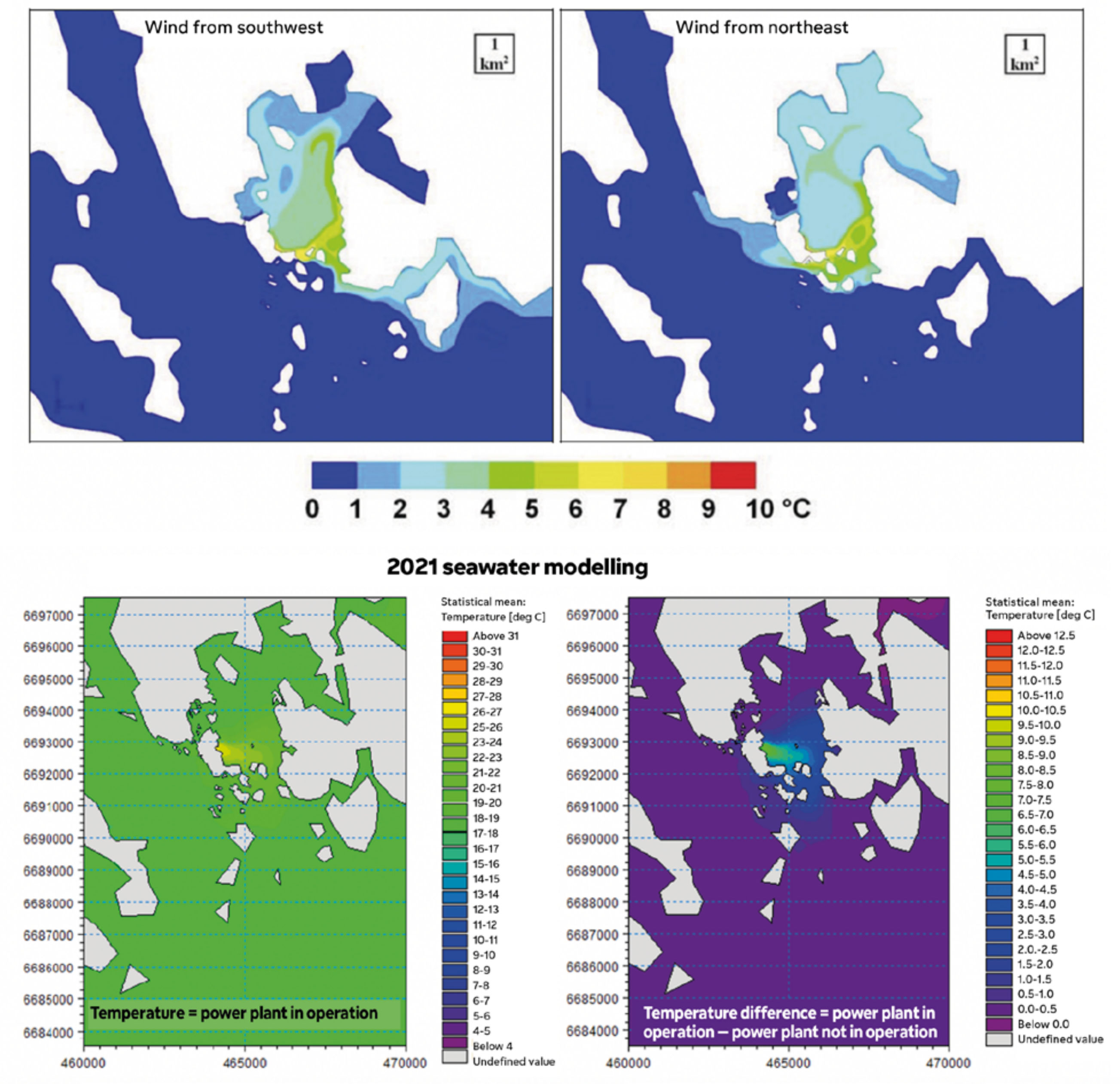


Figure 6-1. The results of the 2008 cooling water modelling (above; Toppila 2008) and the modelling results of this work (below). The maps show the average surface temperature of seawater in summer conditions.

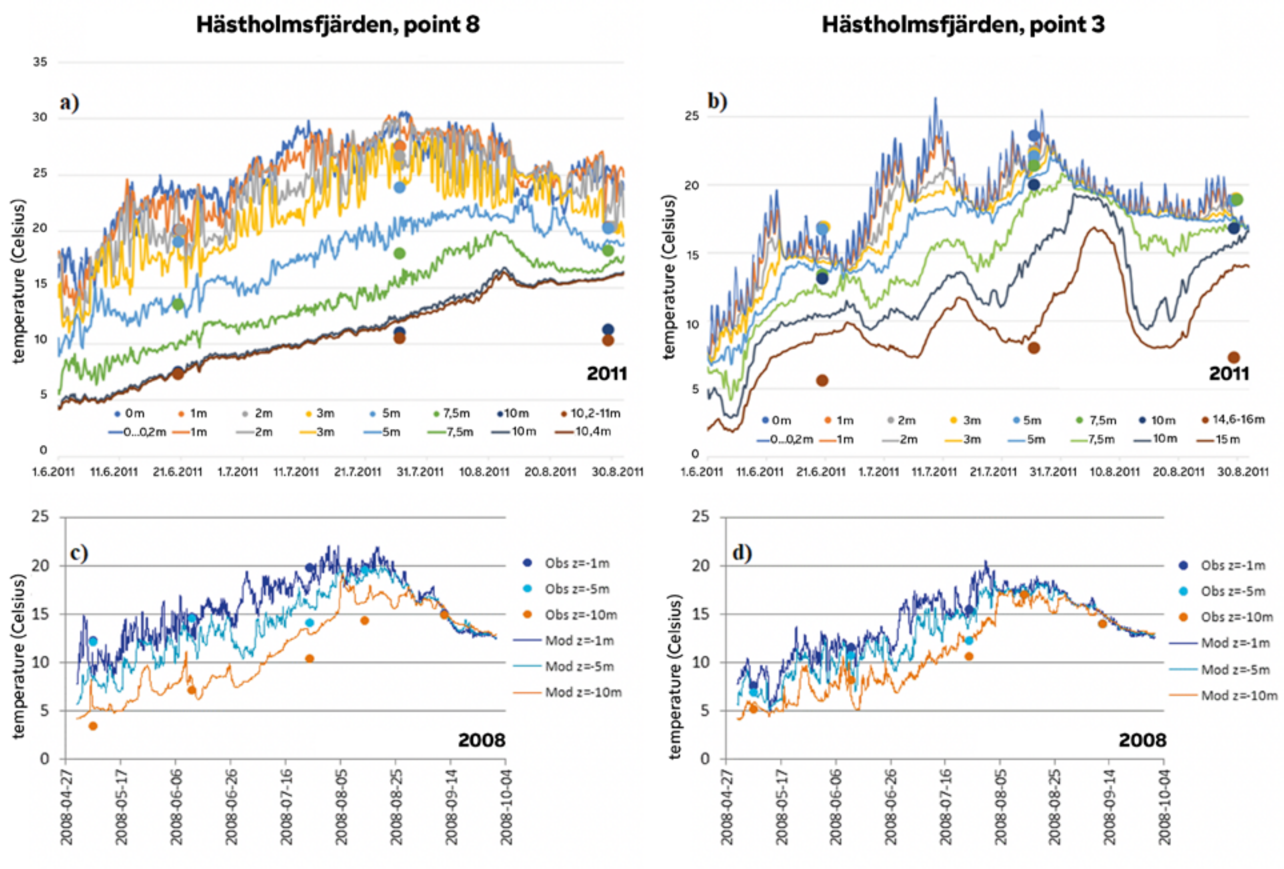


Figure 6-2. The modelled (unbroken lines) and observed (circles) seawater temperatures at Hästholmsfjärden's point 8 and Hudöfjärden's point 3 based on the modelling carried out in this work (2011) and the modelling carried out in 2010 (2008; DHI 2010).

Figure 6-3 shows the average and maximum surface temperatures of water based on the cooling water modelling estimated for the ice-free seasons in 2011 and 2009. The 2011 images are the modelling results of this work, and the 2009 images are the results of the cooling water modelling carried out in 2010 (DHI 2010). When comparing the images, attention should be paid to the different colour schemes of the temperatures. One should also note that the modelling has been carried out in different years, due to which the temperatures cannot be expected to entirely correspondent, particularly since 2011 was quite warm.

Based on the average images (Figure 6-3, the top images), it can be concluded that in both cooling water modellings, the cooling water spreads nearly to the same area on the surface. Regarding 2011, warm water would also seem to be spreading to a wider area south of Hästholmen, but this impression is largely attributable to differences in the scopes of the colour schemes. This also becomes clear when the maximum surface temperatures are examined, given that Figure 6-3 d) also shows the cooling water spreading beyond Hästholmsfjärden. The difference between the years can also be seen from the images of maximum surface temperatures, because the 2011 surface temperatures are significantly higher than the 2009 surface temperatures, even beyond the power plant's thermal effect. However, in terms of their general characteristics, the results are fairly conformable.

The results of the cooling water modelling carried out in this work depart to some degree from the 2008 cooling water modelling, conducted with a considerably simpler model. Indeed, the differences between the results of the models primarily describe the constraints of the simpler model. When comparing the results of the cooling water modelling in this work to the modelling conducted in 2010, the results correspond with each other quite well in terms of their general characteristics. The 2010 modelling was conducted with software similar to the software used in this work.

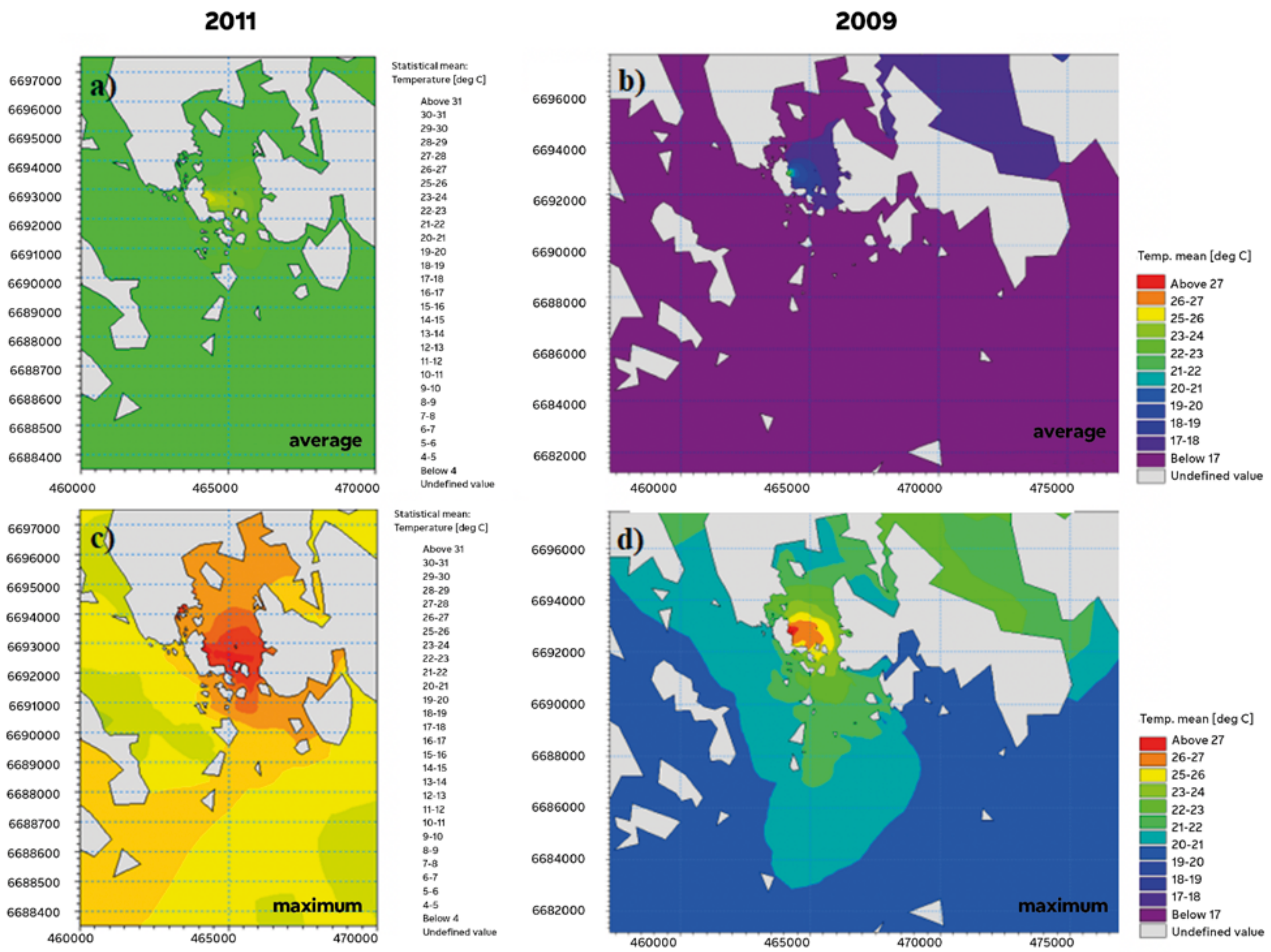


Figure 6-3. The modelled average (a and b) and maximum (c and d) surface temperatures of seawater for 2011 and 2009. The 2011 results were the results of this work.

6.2 ICE SEASON

The effect that Loviisa power plant's warm cooling water has on the ice cover of the nearby sea area has been investigated several times and with different methods during the power plant's history. Figure 6-4 is an example of an ice chart of the power plant's environment drawn up on 14 March 1986. The figure shows that during the time in question, the area of meltwater in the power plant's discharge area was fairly small. The ice winter in 1986 has indeed been classified as a severe ice winter (SMHI 1986).

The carry-over of Loviisa power plant's cooling water and its effect on the surrounding sea area's ice situation was assessed with cooling water modelling in 2008 (Figure 6-5). The figure on the left shows the areas of meltwater (blue) and weakened ice (turquoise) caused by the power plant's operation based on the modelling when, at the beginning of the modelling, the ice cover was absolute and the situation otherwise undisrupted. The figure on the right shows the area into which the cooling water disperses according to the modelling. The 2008 cooling water modelling was conducted with average environmental conditions, due to which the results are not representative of any particular period and describe the situation more broadly over a longer period of time. Based on the results of the 2008 modelling, the entire area of Hästholmsfjärden, part of Vådholmsfjärden and areas located close to Hästholmen in Hudöfjärden are typically areas of meltwater or weakened ice during the winter. The estimate of the area into which the cooling water spreads based on the modelling follows the area of meltwater and weakened ice, with the exception of the branch moving west underneath the ice. (Toppila 2008)

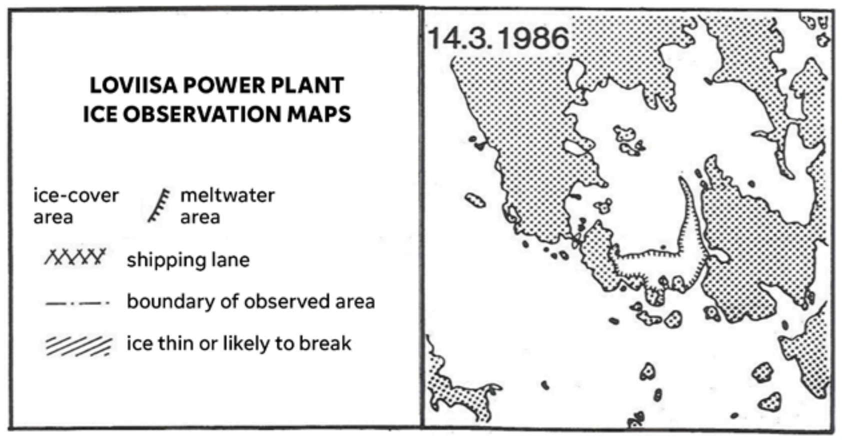


Figure 6-4. An ice chart from the vicinity of Loviisa power plant on 14 March 1986 (Hari 1986).

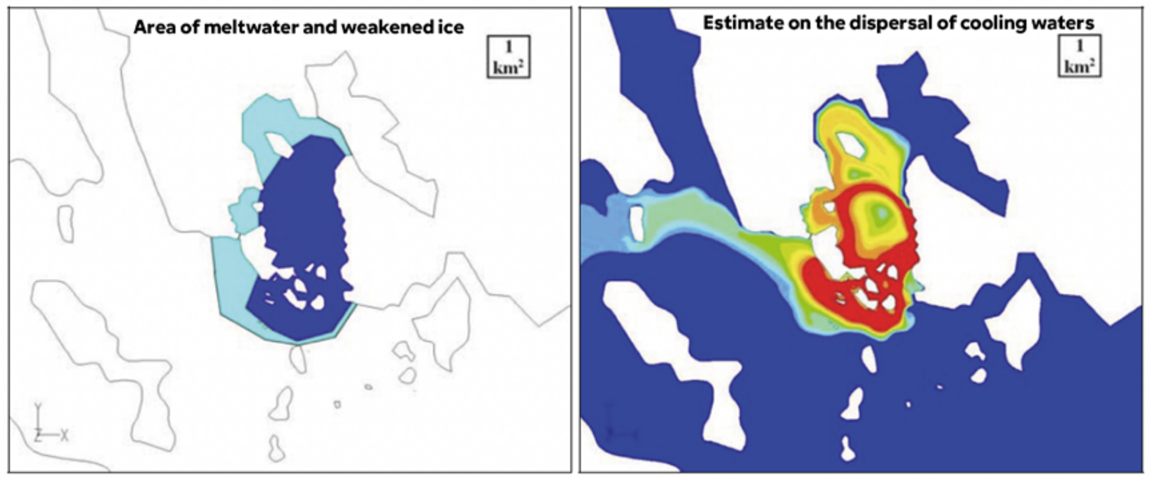


Figure 6-5. Results of the cooling water modelling conducted in 2008: area of meltwater and weakened ice (on the left), and an estimate of the area into which cooling water spreads (on the right). The modelling was conducted under the average environmental conditions of a longer period of time (Toppila 2008).

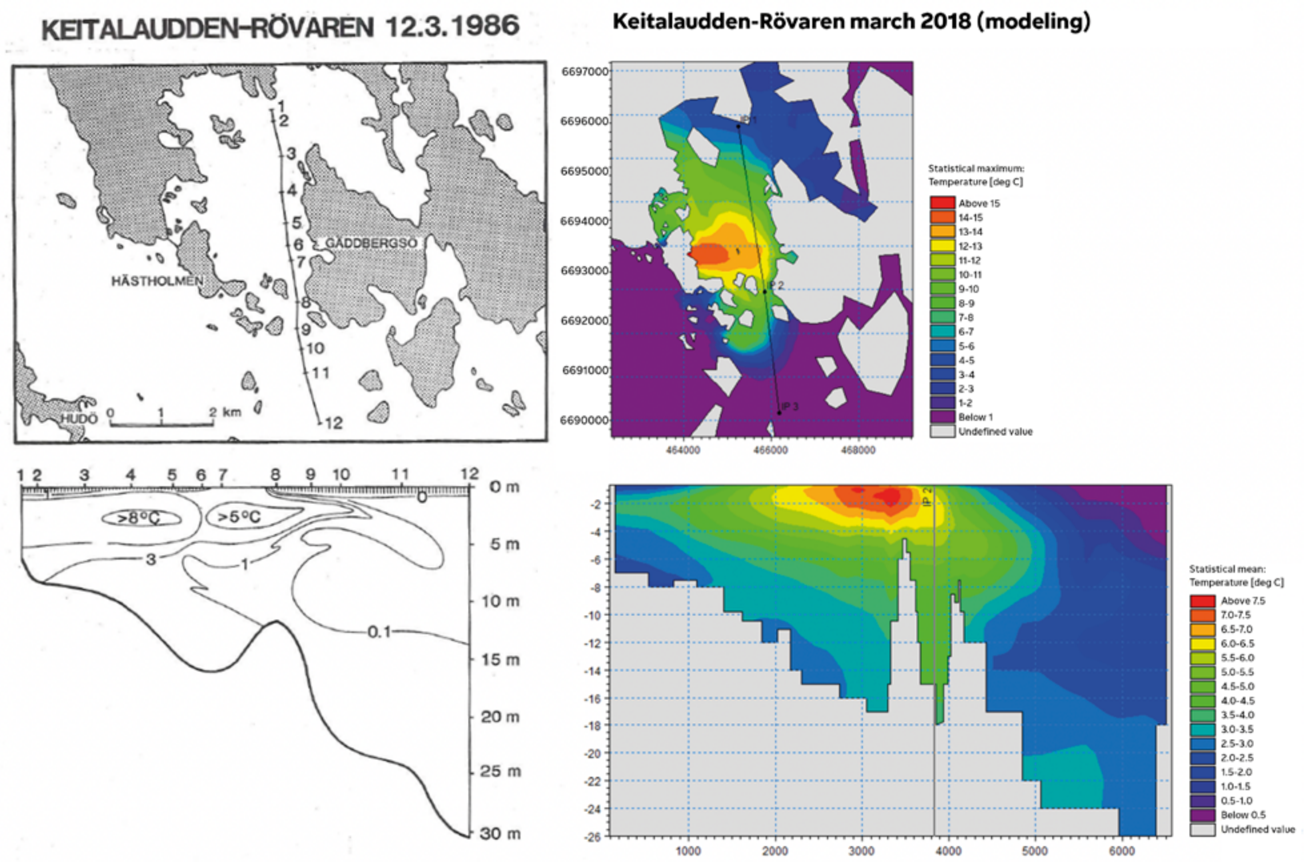


Figure 6-6. The temperature profile (lower left) measured along the line (upper left) on 12 March 1986 (Hari 1986) and the profile of the seawater temperature modelled for this work in the conditions of March 2018 (lower right) determined along a line (upper right) nearly identical to the measurements.

Figure 6-6 shows the seawater's measurement-based temperature profile on a line extending from Hästholmsfjärden to Vådholmsfjärden on 12 March 1986 (images on the left). The figure also shows a map image of the maximum surface temperatures based on the seawater temperature modelling carried out in this work (upper right-hand side) and along a line close to the measurement results, a profile of the average temperature from March 2018 according to the modelling (lower right-hand side). The measurement and modelling results are from different years, so their absolute temperature values cannot be expected to correspond with each other. In addition, the modelling results in terms of the surface temperature describe the maximum temperatures in March, and in terms of the profile, the average temperatures in March, whereas the measurement results describe the seawater's temperature conditions on an individual day. However, in accounting for these differences, clear similarities in the shapes of the temperature profiles can be observed. In both cases, the maximum temperatures occur around the mid-section of the cross-sectional line, although in terms of the measurements, the warmest water is located slightly further to the north than in the modelled situation. Another thing common to both cases is the rapid drop in temperatures when entering Vådholmsfjärden. Furthermore, the temperature values in the profile images (Figure 6-6, bottom images) are in the same region.

Figure 6-7 shows satellite images taken on a few days in March 2018. The area of meltwater is visible in the figure as black and dark blue in the power plant's environment. The areas which have been frozen for a longer period of time are visible in the figure as white, whereas the grey area between the melt and long-term ice is recently formed ice. The series of images shows that the ice situation varied quite a lot over the month. By comparing the surface water's maximum monthly temperature according to the cooling water modelling (Figure 6-6, upper right) with the satellite observations in Figure 6-7, we can see that the model map's 3–4 °C isotherm quite precisely limits the area which, according to the satellite observations, has been ice-free at some point during the month. The model has also been quite successful in depicting the extent of melting in the straits leading to Hudöfjärden and Vådholmsfjärden.

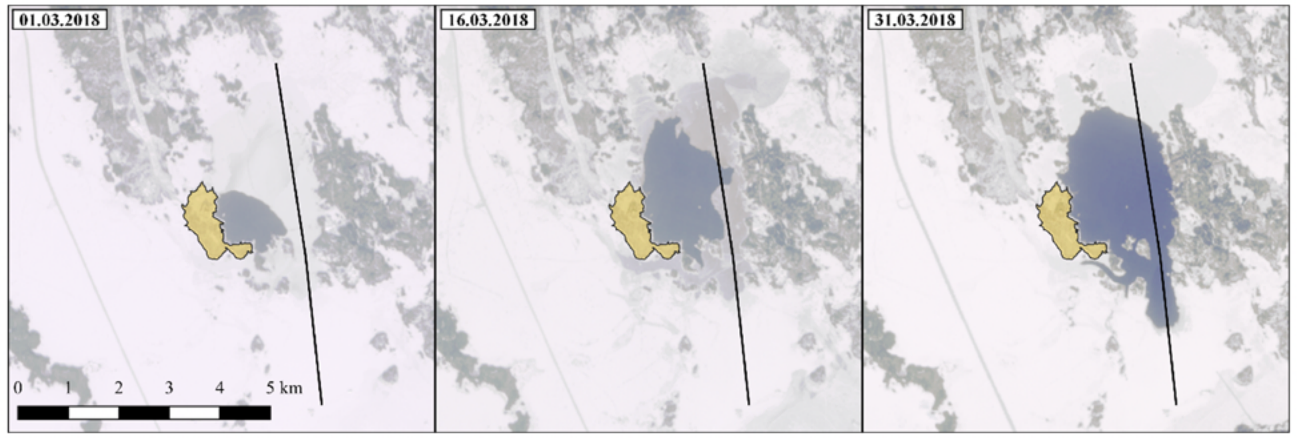


Figure 6-7. Satellite images from the environs of Hästholmen on 1 March, 16 March and 31 March 2018. Hästholmen is marked on the image in orange and the cross-section line of Figure 6-6 as a black line. ESA Copernicus Sentinel Data, Syke (2018).

Assessments based on previous reviews have assumed that after leaving Hästholmsfjärden through the southern straits, the warmed cooling water turns west, in line with the average flow conditions in the Gulf of Finland. Typically, the warmed cooling water settles at a depth of 2–3 m, but occasionally, the settlement depth is 4–5 m. (Ilus 2009)

With regard to the modelling results of this work, the review also covers the westward dispersion of the cooling water beneath the ice, projected by the model. Figure 6-8 shows the cross-sectional line under examination from the discharge location of the power plant's cooling water through the straits in the south to the strait between Hudö and Lindholmen. Figure 6-9 shows the average temperature profile of the cross-sectional line pursuant to Figure 6-8, and Figure 6-10 shows the profile of maximum temperatures during March 2018. It can be seen from the profile images that based on the modelling, and in terms of both average and maximum temperatures, after sinking under the ice, the core of the warm cooling water settles at a depth of around 4 m. This corresponds well with the views of the behaviour of the cooling water based on earlier reviews. Based on the profile of the maximum temperature, the warm cooling water is carried all the way to the strait between Hudö and Lindholmen underneath the ice, although at this distance, its temperature departs from that of the surrounding water only slightly, or by roughly 0–0.5 °C. However, due to the shortish calculation period, the long-range transport of the cooling water does not reach an equilibrium, which means that, in reality, the warm cooling water is transported even further. Based on the profile images (6-9 and 6-10), the warm cooling water remains close to the surface in the area of the straits south of Hästholmsfjärden, where, forced by bed formations, it can rise to the underside of the ice cover, causing the ice to melt or weaken. This makes safe passage on ice in the area more difficult.

The results of the cooling water modelling during the ice season carried out in this work conform quite well with the measurement results and satellite images. In addition, the modelling results of this work correspond quite well with the results of the modelling carried out with the simpler cooling water model in 2008. Based on these comparisons, the results of the cooling water modelling for the ice season in this work are sensible and credible.

6.3 NATURA AREA

Figure 6-11 shows the maximum difference of the water's surface temperature according to the cooling water modelling during the ice-free season. The difference has been calculated by subtracting the surface temperature of the situation "power plant not in operation" from the surface temperature of the situation "power plant in operation". In other words, the figure indicates the degree to which the power plant's operation affects the surface temperature of the seawater in nearby areas. The boundaries of the nearby Natura area are also shown in the figure. As is evident from the figure, the thermal effect on the Natura area attributable to the power plant on the basis of the modelling, even in the case of the maximum temperature differences, is small, principally in the region of 0–1°C. At its greatest, the effect can be 1.5–2.0 °C at the Natura area's sharp headland extending to Vådholmsfjärden. Any situations involving maximum temperature differences are nevertheless short-lived, and in average conditions, the thermal effect of the power plant's operation does not, in essence, extend to the Natura area at all during the ice-free season.

Figure 6-12 shows the maximum difference of the water's surface temperature according to the cooling water modelling during the ice season. As in Figure 6-11, the boundaries of the nearby Natura area are marked in the figure. Based on the modelling, the figure shows that the thermal effect caused by the power plant does not extend, during the ice season and in terms of surface temperatures, to the Natura area, even in the case of maximum temperature differences.

Nevertheless, based on Figures 6-8...6-10, it can be concluded that the warm cooling water may be transported to the Natura area beneath the ice. However, even in the case of maximum temperatures, the thermal effects are small (in the region of 0–1 °C).

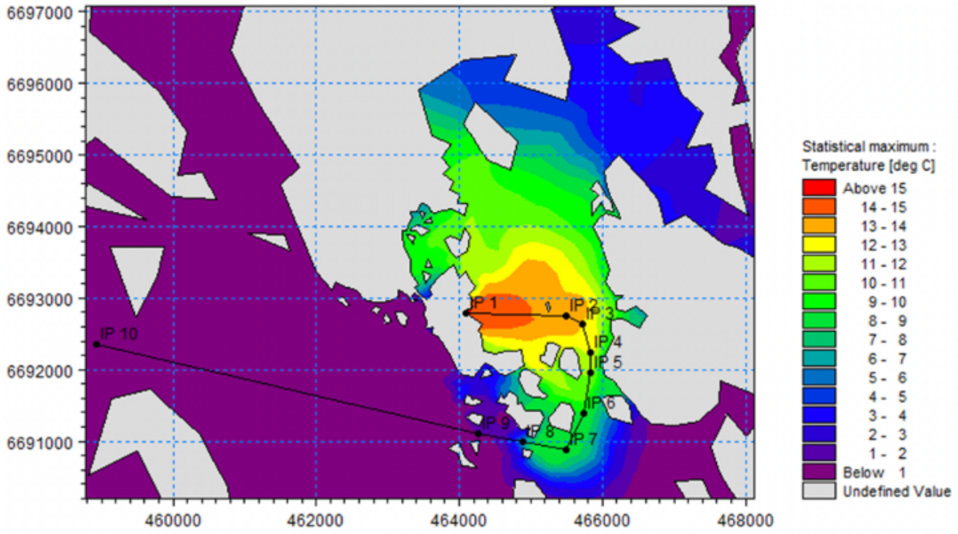


Figure 6-8. The maximum surface temperatures in March 2018 according to the cooling water modelling in this work. The figure also shows the cross-sectional line as a black line.

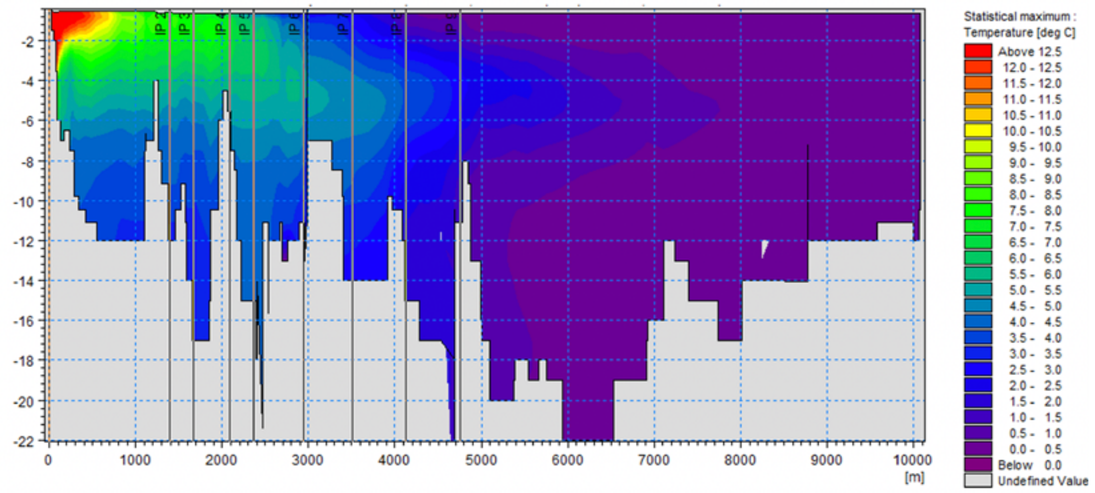


Figure 6-9. The profile of the average temperature according to the cooling water modelling in this work along the cross-sectional line of Figure 6-8.

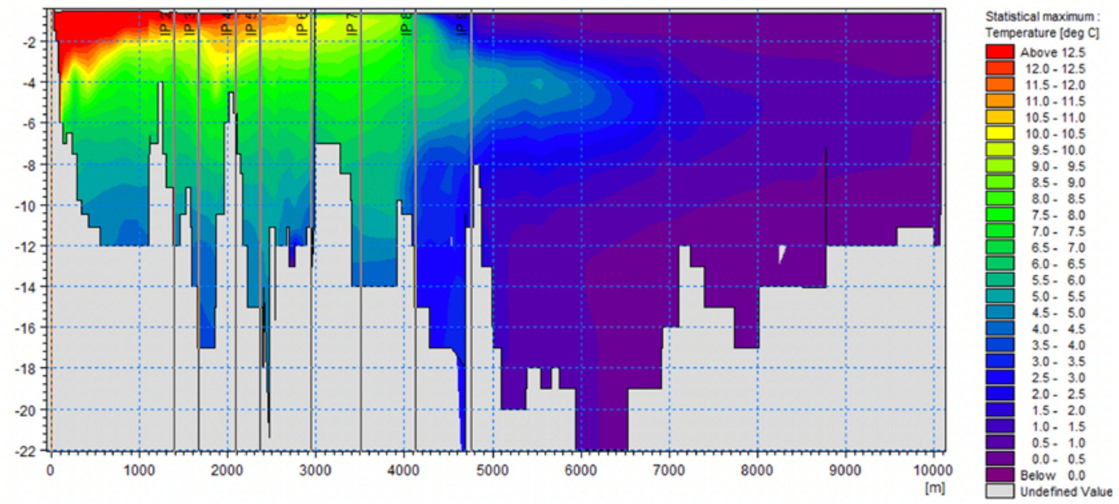


Figure 6-10. The profile of the maximum temperature according to the cooling water modelling in this work along the cross-sectional line of Figure 6-8.

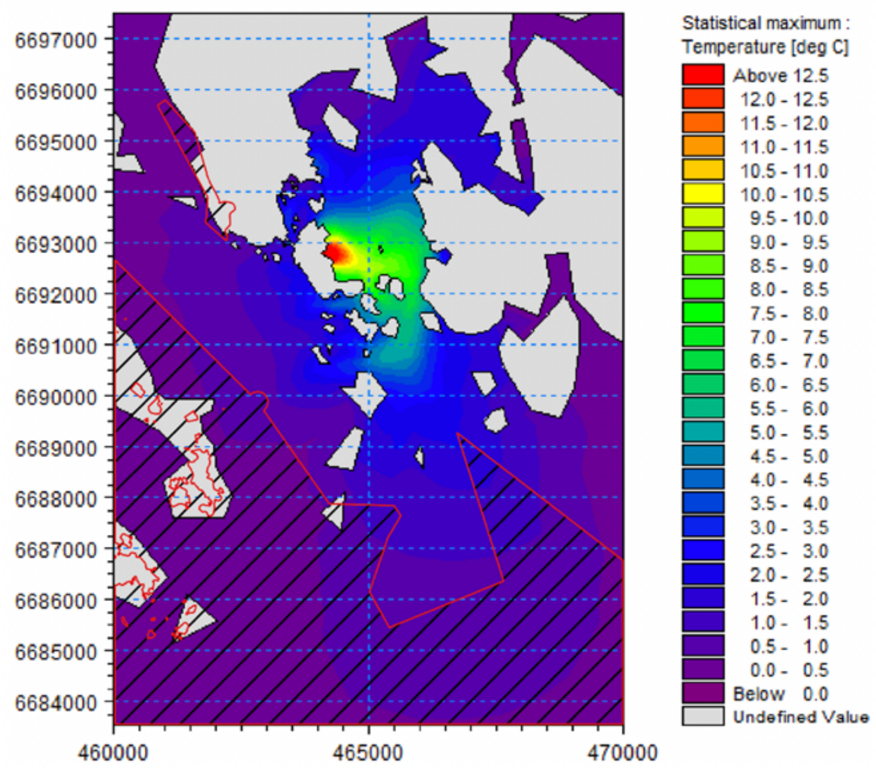


Figure 6-11. The maximum difference in surface temperature (power plant in operation – power plant not in operation) according to the modelling during the ice-free season. The hatched area delimited in red is the Natura area (Syke 2020, Creative Commons 2021).

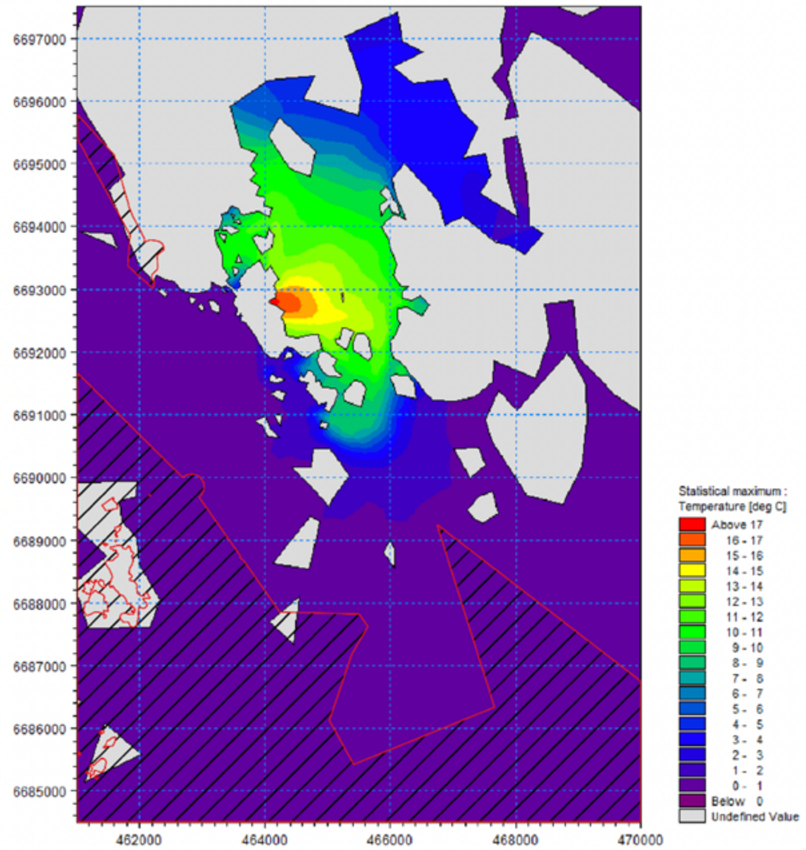


Figure 6-12. The maximum difference in surface temperature (power plant in operation – power plant not in operation) according to the modelling during the ice season. The hatched area delimited in red is the Natura area (Syke 2020, Creative Commons 2021).

7. Summary

The cooling water modelling in this work was conducted with DHI's Mike 3 FM non-hydrostatic flow model (DHI 2017), the baseline data of which include wind conditions, the sea level (variations included), air temperature, ice cover, and components of the net radiation of the sea and atmosphere. The model was calibrated by comparing the calculated values to the observations made during the 2011 ice-free season. Comparisons with earlier modelling results and observations show that the results of the cooling water modelling conducted for this report are sensible and credible from a qualitative perspective.

Based on the results of this modelling report and the results of Loviisa power plant's impact monitoring, the warming effect attributable to the cooling water is primarily visible in the surface layer of the sea area's discharge side, i.e. Hästholmsfjärden. During the summer, the average temperature of the seawater, based on the modelling, may rise by several degrees at the surface, but only in a small area of Hästholmsfjärden, in the immediate vicinity of the discharge location. Based on the modelling, the average increase in temperature in the surface water of Klobbfjärden's entire body of water (Hästholmsfjärden + Klobbfjärden) is, at maximum, only around 1 °C. Temporarily, the surface temperature of the seawater may rise in a broader area on the discharge side, given that the cooling water is often transported for some distance, according to the wind conditions, before mixing with the water column.

During the ice-free season, heat is also transferred efficiently from the seawater into the atmosphere, which contributes to a reduction in the warming effect of the power plant's cooling water during the growth season, for example. In winter, the cooling water can be transported even further underneath the ice, because the ice cover prevents the transfer of heat into the atmosphere and the wind's impact on mixing layers of water. In winter, the warm cooling water also weakens the ice cover in the nearby sea areas of Hästholmsfjärden, particularly in the area of the southern straits, where land forms may direct the warm water towards the surface of the water and the ice cover. According to the modelling results, cooling water that is warmer than the surrounding water column is transported beneath the ice fairly far to the west across Hudöfjärden, at a depth of approximately 4 m. This corresponds very well with the results of earlier studies.

Based on the modelling results, the cooling water's thermal effect in the nearby Natura area is very small during both the ice-free season and the ice season. During the ice-free season, the thermal effects extend to the Natura area only temporarily, when the wind drives the flow of water towards the area. During the ice season, the warmed cooling water discharged by the power plant can be transported further beneath the ice, often all the way to the Natura area, but the thermal effect is typically small.

When thinking about average temperatures, climate change will warm the surface of the sea by several degrees across the entire area, compared to which the warming caused by the power plant is limited to a very small area, particularly since the power plant's operating conditions restrict the temperature of the water to be discharged during warmer times.

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Appendices

APPENDIX 1: MAXIMUM ICE EXTENT IN THE BALTIC SEA DURING ICE WINTER 2017–2018 – ICE CHART

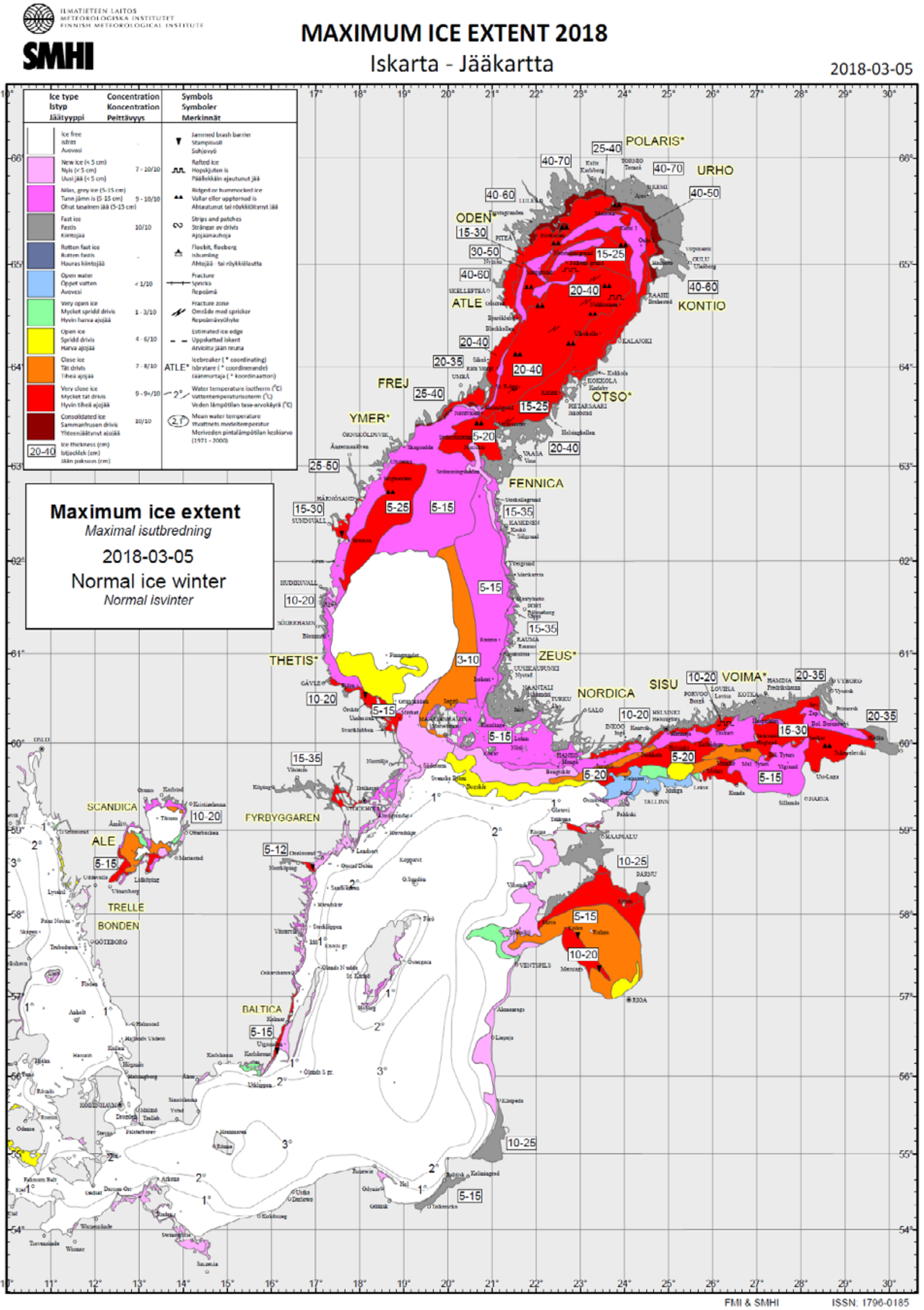

Figure L1-1.

APPENDIX 2: TIME SERIES OF MODELLING RESULTS BY RECEIVER POINTS DURING ICE-FREE SEASON

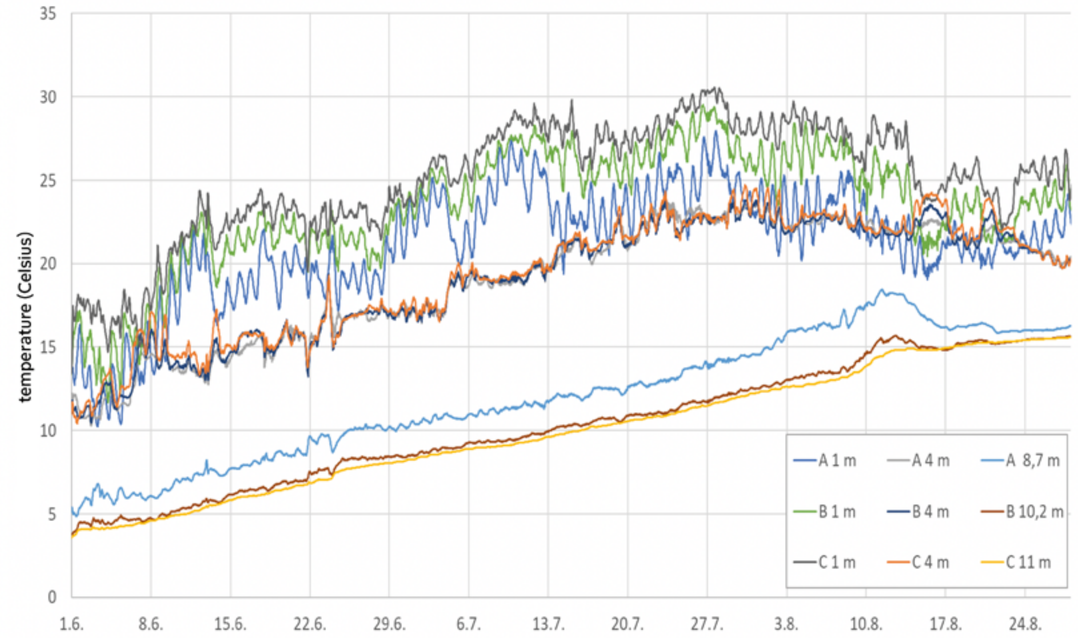

Figure L2-1. The modelled water temperature at various depths and buoys A, B and C on the discharge side in Hästholmsfjärden in 2011 weather conditions, operation of power plant continues.

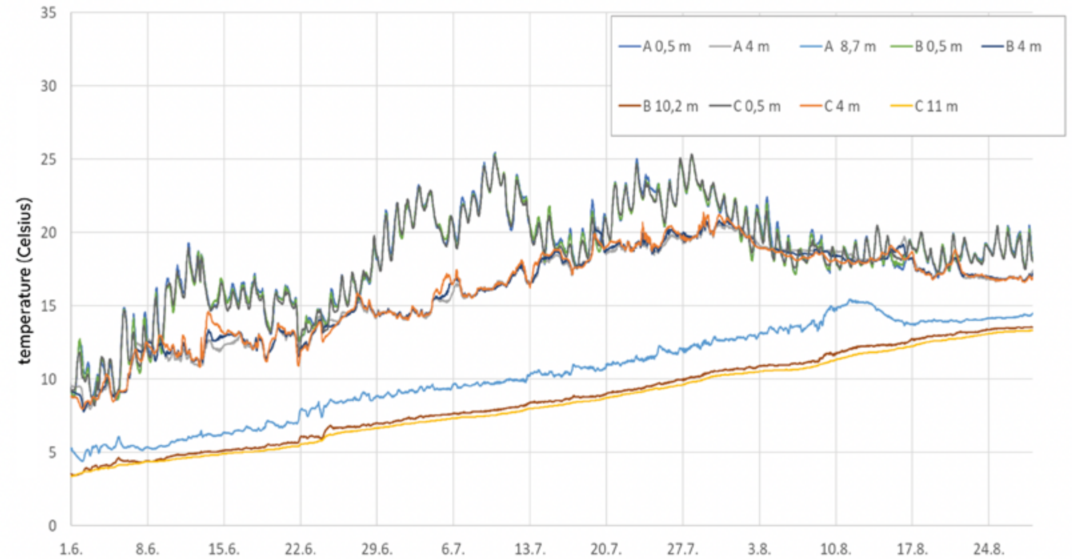

Figure L2-2. The modelled water temperature at various depths and buoys A, B and C on the discharge side in Hästholmsfjärden in 2011 weather conditions, power plant decommissioned.

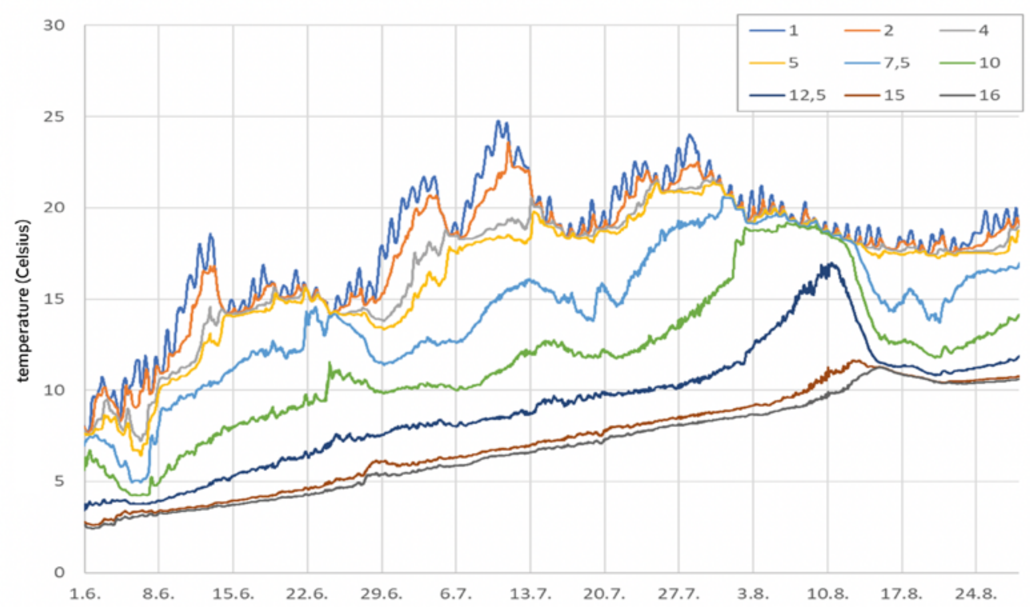

Figure L2-3. The modelled water temperature at various depths and point K1 in Hudöfjärden in 2011 weather conditions, operation of power plant continues.

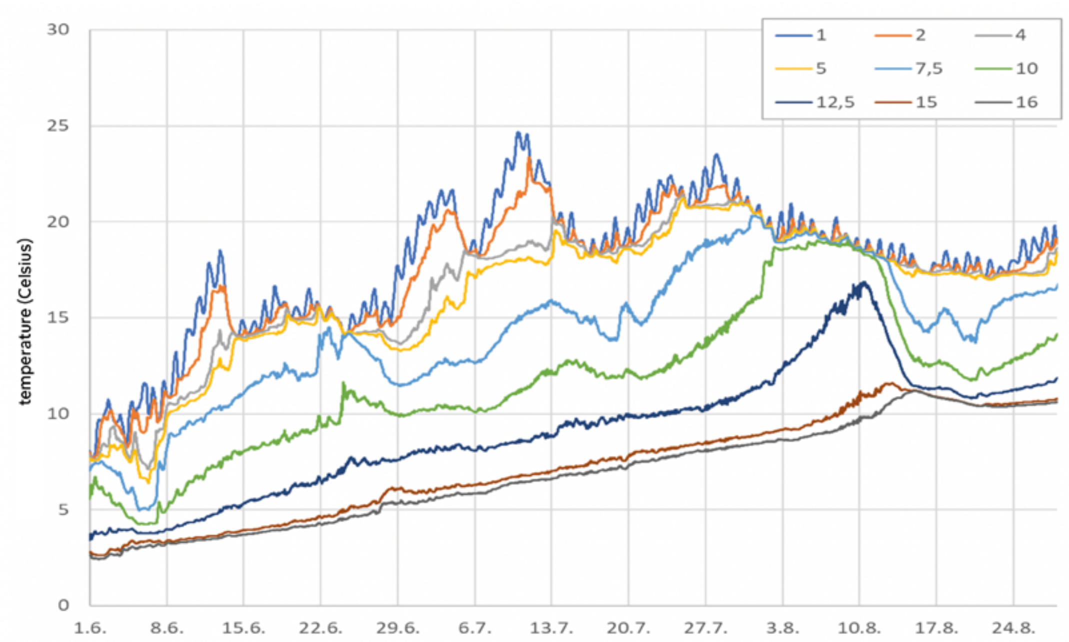

Figure L2-4. The modelled water temperature at various depths and point K1 in Hudöfjärden in 2011 weather conditions, power plant decommissioned.

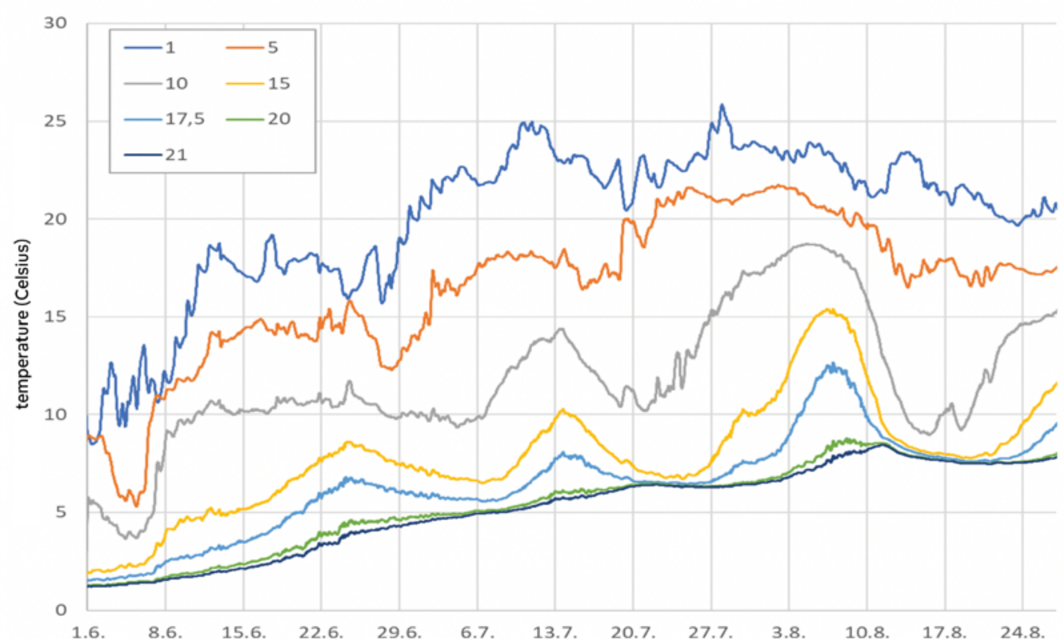

Figure L2-5. The modelled water temperature at various depths and point K2 in Vådholmsfjärden in 2011 weather conditions, operation of power plant continues.

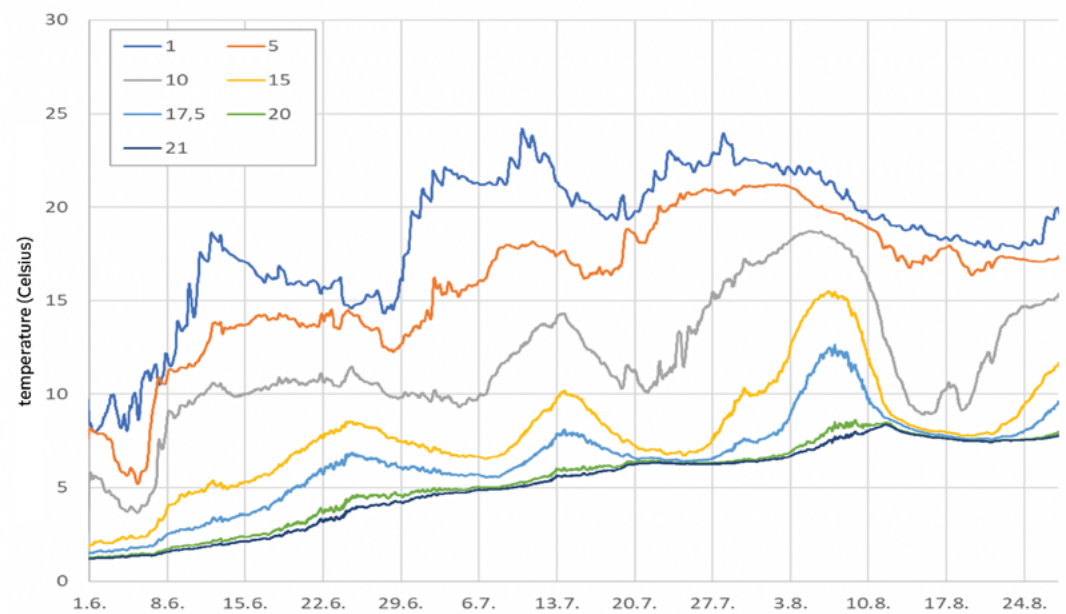

Figure L2-6. The modelled water temperature at various depths and point K2 in Vådholmsfjärden in 2011 weather conditions, power plant decommissioned.

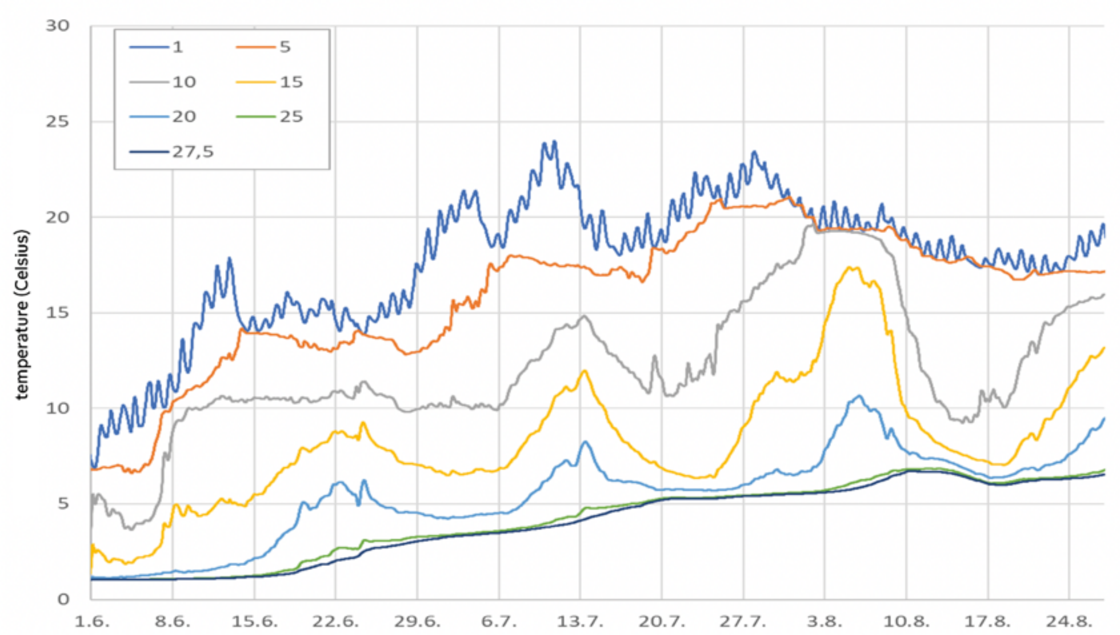

Figure L2-7. The modelled water temperature at various depths and point K3 in Orrengrundsfjärden in 2011 weather conditions, operation of power plant continues.

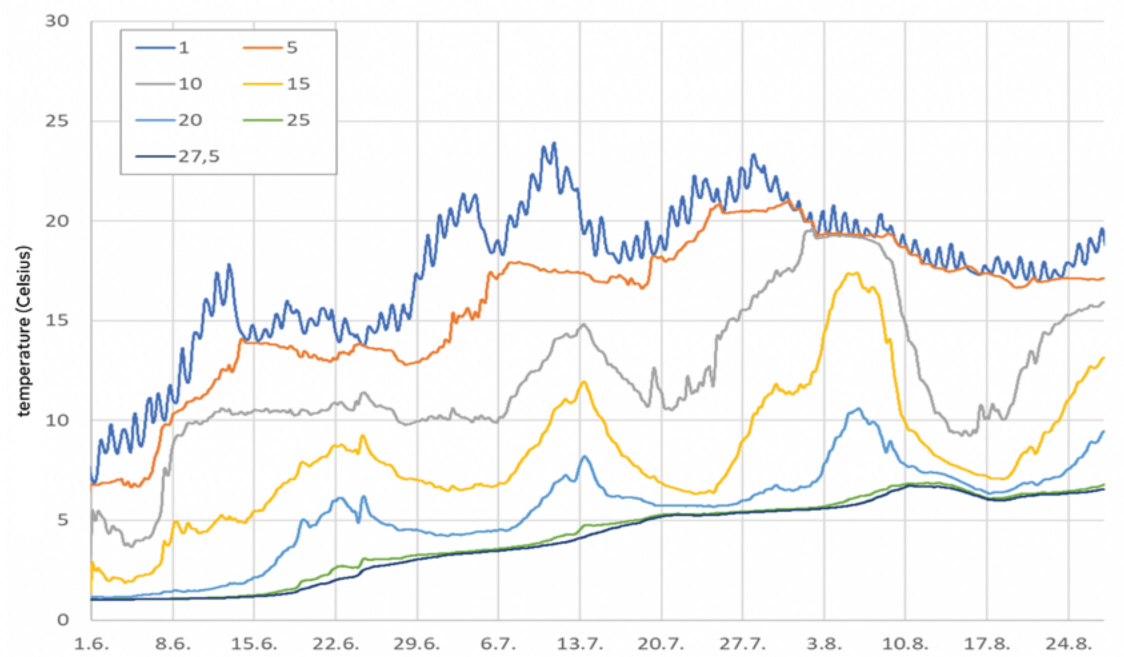

Figure L2-8. The modelled water temperature at various depths and point K3 in Orrengrundsfjärden in 2011 weather conditions, power plant decommissioned.

APPENDIX 3: TIME SERIES OF MODELLING RESULTS BY RECEIVER POINTS DURING ICE SEASON

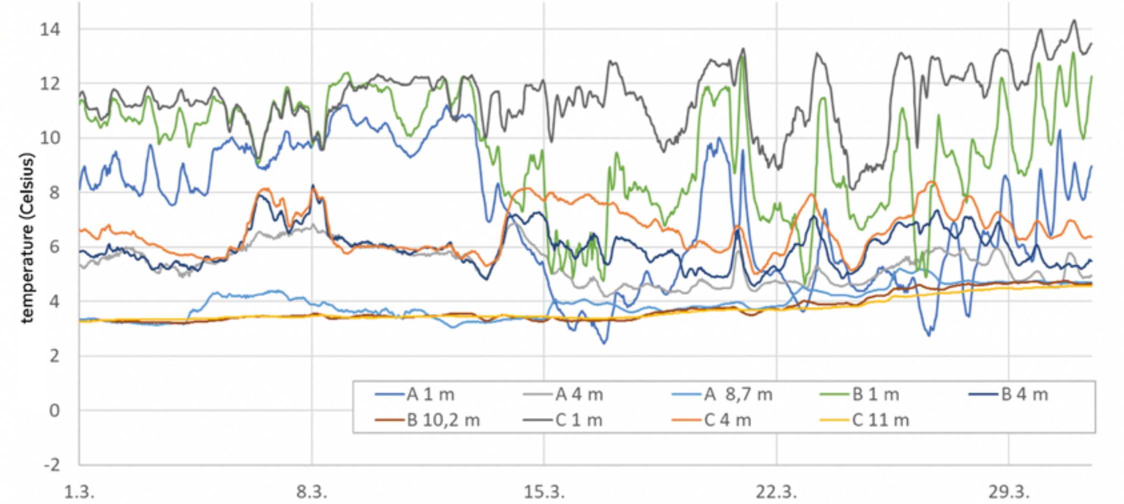

Figure L3-1. The modelled water temperature at various depths and buoys A, B and C on the discharge side in Hästholmsfjärden (Figure 3-3) in March 2018, operation of power plant continues.

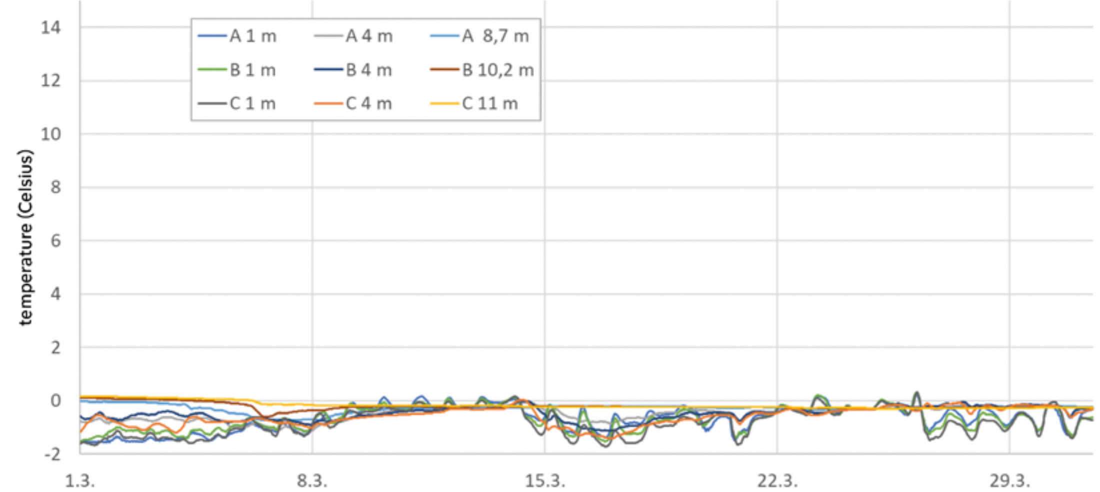

Figure L3-2. The modelled water temperature at various depths and buoys A, B and C on the discharge side in Hästholmsfjärden (Figure 3-3) in March 2018, power plant decommissioned.

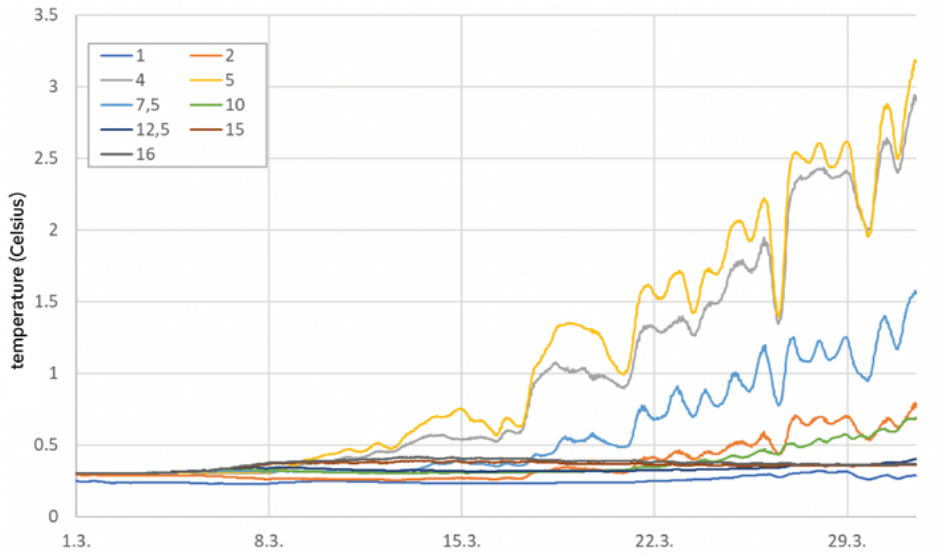

Figure L3-3. The modelled water temperature at various depths and point K1 in Hudöfjärden in March 2018, operation of power plant continues.

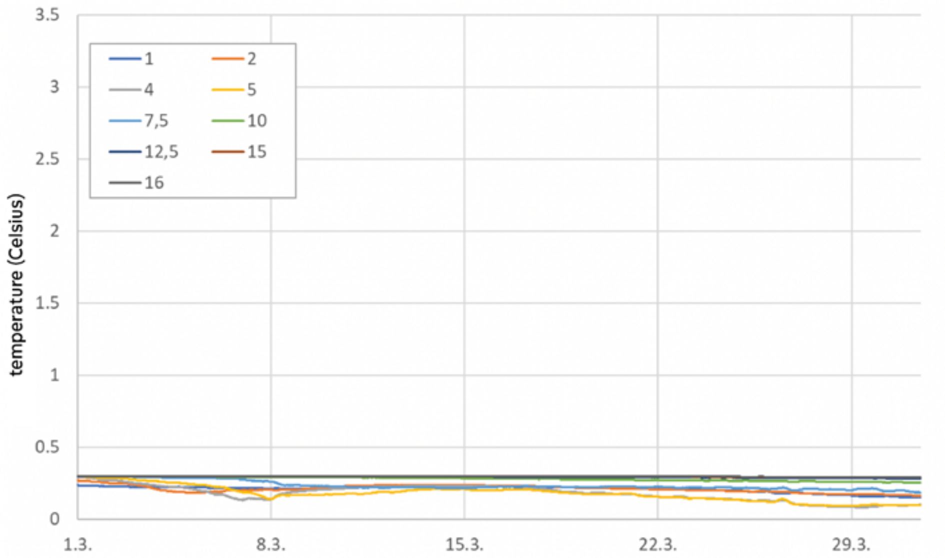

Figure L3-4. The modelled water temperature at various depths and point K1 in Hudöfjärden in March 2018, power plant decommissioned.

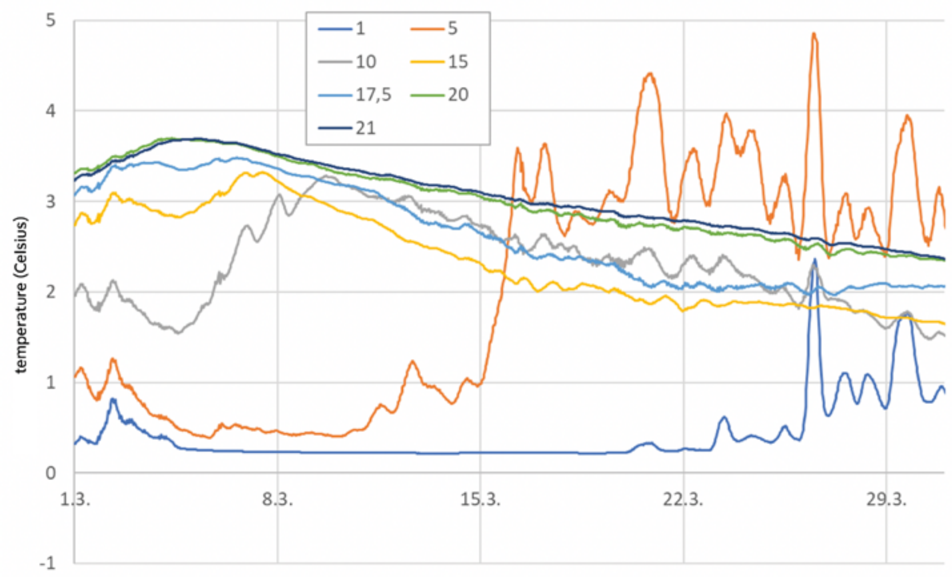

Figure L3-5. The modelled water temperature at various depths and point K2 in Vådholmsfjärden in March 2018, operation of power plant continues.

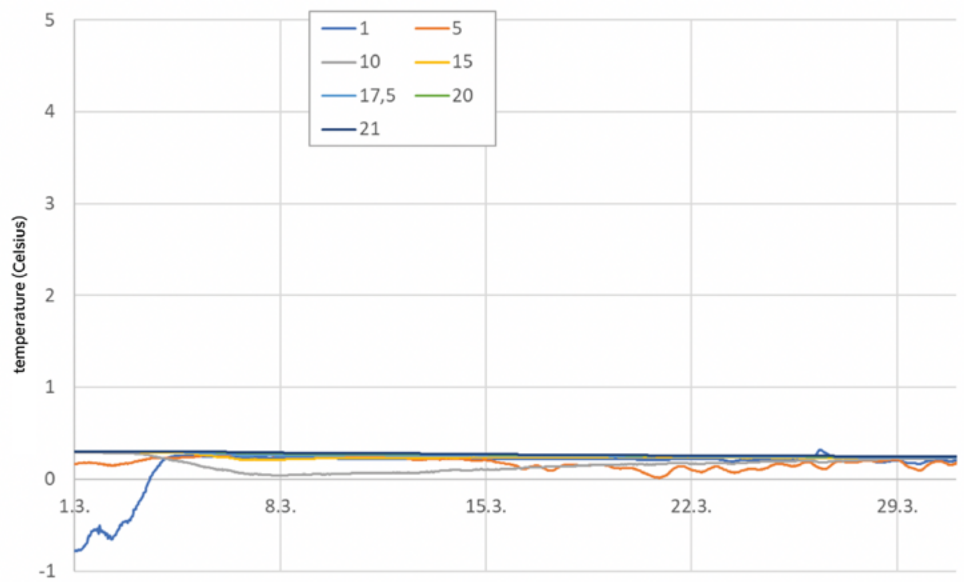

Figure L3-6. The modelled water temperature at various depths and point K2 in Vådholmsfjärden in March 2018, power plant decommissioned.

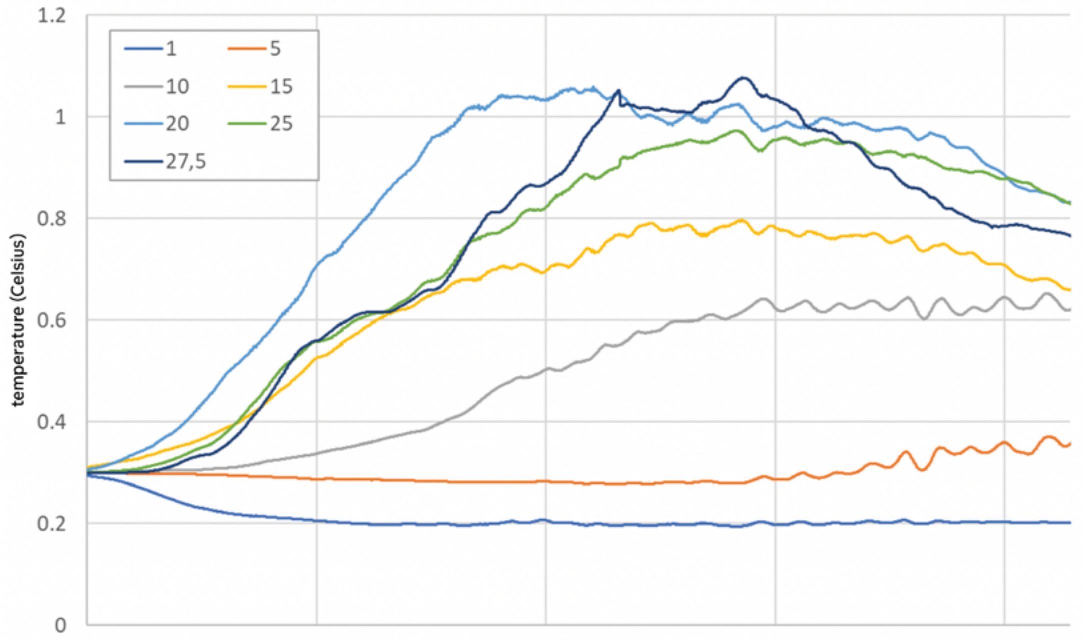

Figure L3-7. The modelled water temperature at various depths and point K3 in Orrengrundsfjärden in March 2018, operation of power plant continues.

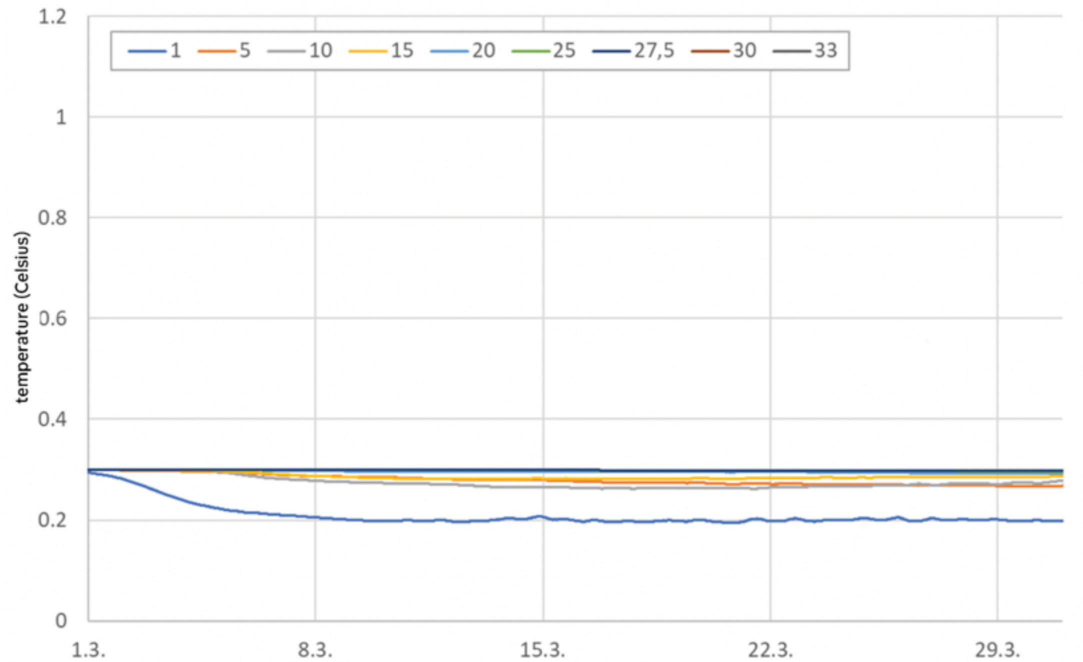

Figure L3-8. The modelled water temperature at various depths and point K3 in Orrengrundsfjärden in March 2018, power plant decommissioned.

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