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Temporal trends in mercury concentrations in eggs of Tawny owl (*Strix aluco*) from Central Norway between 1986-2019: influence of dietary ecological parameters and climate variables

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Master of Science in Biology – Arctic Marine System Ecology

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“Sagesse n’entre pas en âme malveillante et que Science sans Conscience n’est que ruine de l’âme”

Rabelais in Pantagruel

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Thomas Victor Robert Courtin,

In Tromsø, May 2022

Abstract

Mercury (Hg) is considered as a global threat which is emitted in the environment through natural sources or anthropogenic activities. Emissions of mercury decreased during the last decades because of the implementation of mitigation measures. However, with the ongoing climate change, ecosystems are directly (e.g., rising temperature) or indirectly impacted (i.e., altered ecosystem by e.g., invasive species and over-harvesting). Therefore, climate variables should be integrated in assessing pollutant temporal trends. In the current study, we investigated the temporal trends of Hg concentrations over a 33-year period (1986-2019). The potential influence of climate variables (i.e., air temperature, maximum snow depth, and the North Atlantic Oscillation) and dietary ecological parameters (i.e., carbon and nitrogen stable isotopes, ∂^{13}C and ∂^{15}N) on the Hg concentrations in tawny owl eggs were also investigated. Mercury and stable isotope values were analyzed in eggs and the data for the air temperature and the maximum snow depth for the winter period (December-March) were retrieved from several stations surrounding Trondheim. The average values for the three climate variables (i.e., temperature, max snow depth, and North Atlantic Oscillation (NAO)) were calculated for the entire winter period (December-March). A sudden shift in Hg concentrations was observed between 2000 and 2005 while exploring the dataset, two periods (1986-2005 and 2006-2019) were therefore investigated. A significant difference ($p < 0.01$) was observed between the two periods (0.12 ± 0.07 µg.g^{-1} and 0.074 ± 0.039 µg.g^{-1}, respectively). A significant annual decrease of 0.002 µg.g^{-1} in mercury concentration was observed throughout the entire studied period ($t = -5.42$, $p < 0.001$). Among the different models selected to investigate the influence of dietary ecology and the climate variables on temporal trends of Hg, the most parsimonious model included the influence of the temperature and the ∂^{13}C. Therefore, temperature and feeding habitat (∂^{13}C) were found to have a higher influence on egg Hg than trophic level (∂^{15}N), precipitations (snow), and larger scale climate variable (NAO).

Abbreviations

ACF	Autocorrelation function
AIC	Akaike's Information Criterion
AIC_c	Akaike's Information Criterion corrected for small sample sizes
AIC_cWt	AIC$_c$ weight
AMAP	Arctic Monitoring and Assessment Programme
ANOVA	Analysis of variance
BFR	Brominated flame retardant
∂^{13}C	stable carbon isotope value
∂^{15}N	stable nitrogen isotope value
dw	Dry weight
edf	Effective degree of freedom
GAM	Generalized additive model
GEM	Gaseous elemental mercury
Hg	Mercury
HgDw	Mercury concentration (dry weight)
HgWw	Mercury concentration (wet weight)
LM	Linear model
LRT	Long-range transport
MA	Moving average
MeHg	Methylmercury
MS	Maximum snow depth
NAO	North Atlantic Oscillation
NAOI	North Atlantic Oscillation index
OC	Organochlorine
p,p'-DDE	1,1-dichloro-2,2bis (p-chlorophenyl) ethylene
PACF	Partial autocorrelation function
PCB	Polychlorinated biphenyl
PFAS	Per- and polyfluoroalkyl substance
PCB	Polychlorinated biphenyl

PFOS	Polyfluoroalkyl sulfonate
POP	Persistent organic pollutant
SD	Standard deviation
Se	Selenium
T	Temperature
TGM	Total gaseous mercury
THg	Total mercury
UNEP	United Nations Environment Programme
VIF	Variation Inflation Factor
ww	Wet weight
Y	Year

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1. Introduction

Mercury (Hg), a non-essential heavy metal, is considered a major environmental contaminant and occurs naturally throughout the environment as a result of e.g., both submarine and terrestrial volcanic activity, and low temperature volatilization from natural waters and soils (Fitzgerald & Lamborg 2007; Mason 2009; Liu et al. 2012). In addition to the natural occurrence of Hg, anthropogenic activities, such as fossil fuel combustion, mining activities, metal production, and waste disposal, play important roles in atmospheric emissions of Hg (Mason et al. 1994; Gray & Hines 2006). Once released into the environment, Hg can undergo long-range transport (LRT) and contaminate different media (i.e., air, water, soil, biota; Liu et al. 2012). Because of its ability to biomagnify throughout the food chain (Fitzgerald & Lamborg 2007) and its toxicity (Park & Zheng 2012), Hg is detrimental to ecosystems and human health. Namely, Hg has been considered as a serious global threat of major concern for wildlife, ecosystems, and human health for several decades (Lindberg & Turner 1977; Airey 1983; Revis et al. 1990; Björnberg et al. 2003; Mahaffey et al. 2004; Fitzgerald et al. 2005; Goodale et al. 2008; Dastoor & Davignon 2009; Espín et al. 2014; Du et al. 2021; Herbert et al. 2021).

1.1 Origin and transport of mercury

Natural sources of Hg emissions are estimated to 5207 tons per year and represent approximately 70% of the total emissions (7527 tons in total per year; Pirrone et al. 2010). Half of anthropogenic emissions is locally deposited (Mason et al. 1994), and the other half is transported by general atmospheric circulation (Jackson 1997). Hg deposition can be divided in two categories, namely dry (direct deposition from the atmosphere) and wet (precipitations and acidic fogs) deposition (Figure 1; Gustin 2012).

Hg can travel over long distances and even reach remote areas (Fitzgerald et al. 1998). The LRT of Hg can happen through atmospheric currents, oceanic currents, river run-offs, sea-ice and glacier melting, and biotic transport (Figure 2). Hg atmospheric transport occurs on a shorter time scale than Hg oceanic transport (Travnikov 2012). Moreover, despite being mainly distributed throughout the atmosphere under different forms, the major exposure pathways of

Hg to the environment is through precipitation, however, it depends on meteorological conditions (Pirrone et al. 1995).

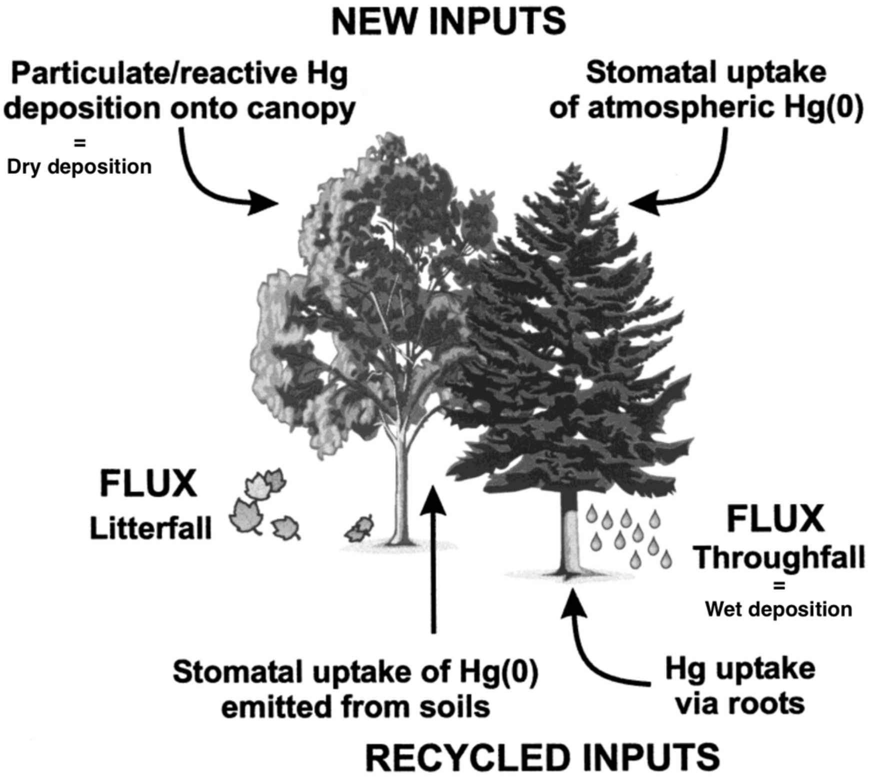

Figure 1: Representation of mercury (Hg) cycling in a boreal forest and its uptake by vegetation (modified from St. Louis et al. 2001). Dry deposition is represented by particulate/reactive Hg deposition onto canopy. Precipitations are represented by throughfall and can convey dry deposited Hg onto leaves to the soil.

1.2 Mercury cycle

Hg exists under three different forms (elemental, inorganic, and organic) that are present in the environment (aquatic ecosystems, soils, and atmosphere) and in organisms (Liu et al. 2012). Elemental Hg, the simplest form of Hg, is liquid at ambient temperature (Vizuete et al. 2018). Under this form, Hg is not readily absorbed but can evaporate due to its high volatility (high vapor pressure at ambient temperature; Ippolito et al. 2012) resulting in Hg vapor. Hg vapor is the predominant form of Hg in the atmosphere while inorganic Hg is predominant in several ecosystems (aquatic, soil, and sediments). Inorganic Hg is formed when Hg is combined with different elements such as phosphorus and sulfur.

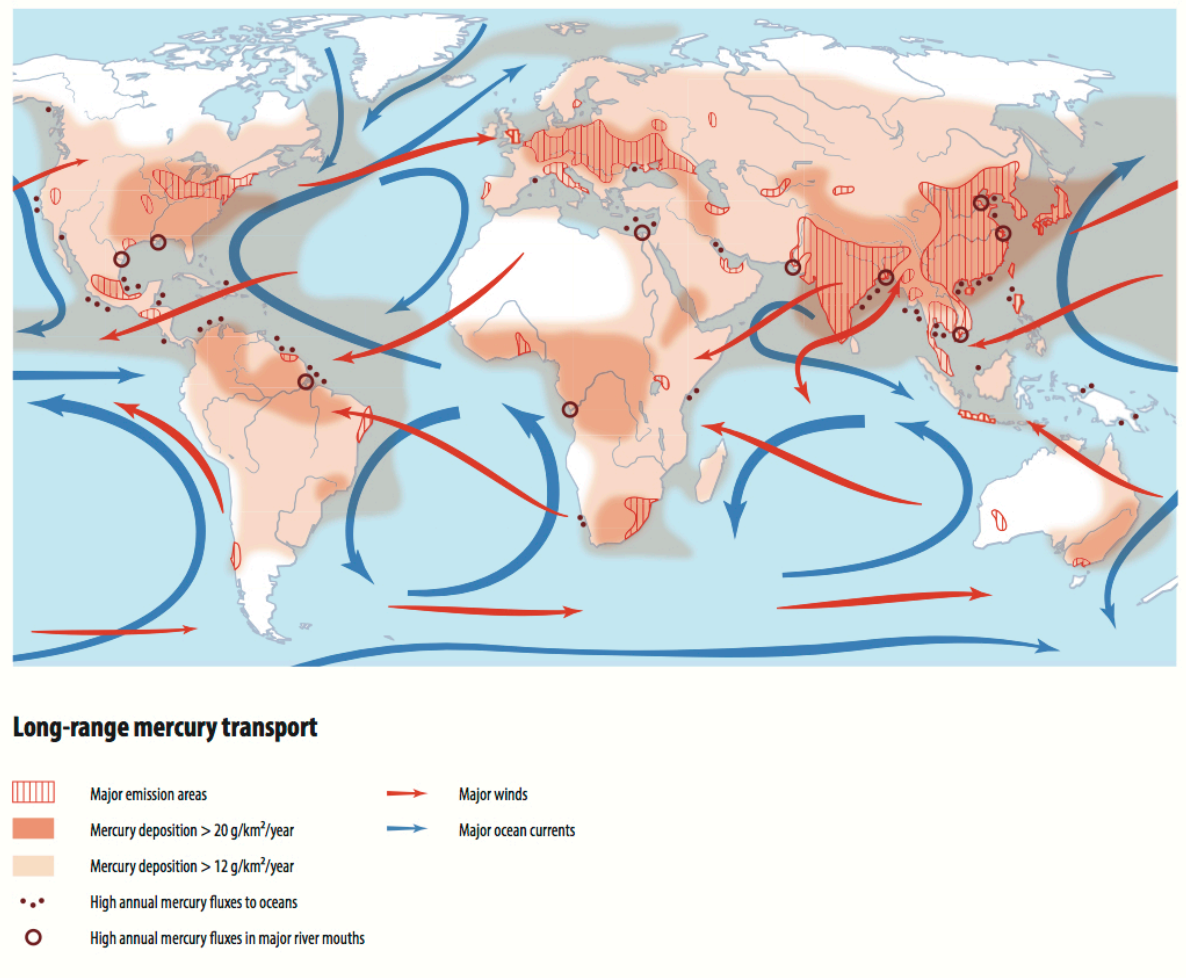

Figure 2: Schematic representation of the long-range mercury (Hg) transport (GRID-Arendal; adapted from AMAP/UNEP 2008; UNEP 2013).

From inorganic Hg, and primarily under the action of micro-organisms, organic Hg is formed when combined with carbon (Fitzgerald & Lyons 1973; Risher et al. 2002). As a consequence of predominance of the inorganic form in different ecosystems, ocean, soil and sediments are considered as sinks for Hg (Gustin et al. 2008; Gustin 2012). Depending on the characteristics of the system, and the possible disturbance of it, Hg can be sequestered for a more or less long period of time (Gustin 2012). Organic Hg, with methylmercury (MeHg) being the most abundant (Risher et al. 2002) is predominant in biota (Liu et al. 2012).

The north of the Palearctic Region is mostly composed of boreal forests (Moen 1987; Sunde et al. 2001) where soil is more acid (i.e., pH < 7) and heavy metals more bioavailable due to the facilitated binding between Hg and organic matter (Gabriel & Williamson 2004). Despite an increased bioavailability of MeHg, the absorption of Hg by plants is low (roots act as barrier;

Patra & Sharma 2000). To enter the food web, Hg must be in a chemical form and in a location where it is readily accessible to biota (AMAP 2011).

1.3 Bioaccumulation, biomagnification, and toxicity

Among the different metals, only a few, including Hg, can accumulate throughout the food webs (Kidd et al. 2012). Once Hg has entered the food web, either in its inorganic or organic form, only MeHg biomagnifies (AMAP 2011; Kidd et al. 2012).

While bioaccumulation is defined as the increase of contaminant concentration within one individual over time, biomagnification is a process where the predator's contaminant concentration is higher than that of its prey (Kidd et al. 2012; Figure 3). As a result, concentrations in upper trophic organisms are higher than in primary producers or consumers. Top predatory species, which are often long-lived and feed at the top of their food chain, are found with the highest pollutant concentrations (AMAP 2011). As described in Kidd et al. (2012), in terrestrial ecosystems, Hg concentration in a specific species will also depend on local anthropogenic activities (e.g., agriculture and pesticide use), local conditions (e.g., soil acidity; Mirsal 2008), and dietary ecology (Evers et al. 2005).

Alongside its biomagnification potential, MeHg is also highly toxic and persistent, and can have adverse effects not only on wildlife (Wolfe et al. 1998; Kershaw & Hall 2019) but also on human health (Bose-O'Reilly 2010; Ha et al. 2017). Hg has been associated to central nervous system damage (Abbaslou & Zaman 2006) including the neurological Minamata disease (Yorifuji et al. 2013), cardiac disease (Houston 2014), respiratory syndromes (Rowens et al. 1991), and teratogenic effects (Hsi et al. 2014).

1.4 Regulation

Since the mid-1960s with the publication of the book "Silent Spring" by Carlson R.L. and the growing scientific concern for the "acid rain", the United Nations held a convention in Geneva (1979) to implement mitigation measures regarding the pollutant emissions.

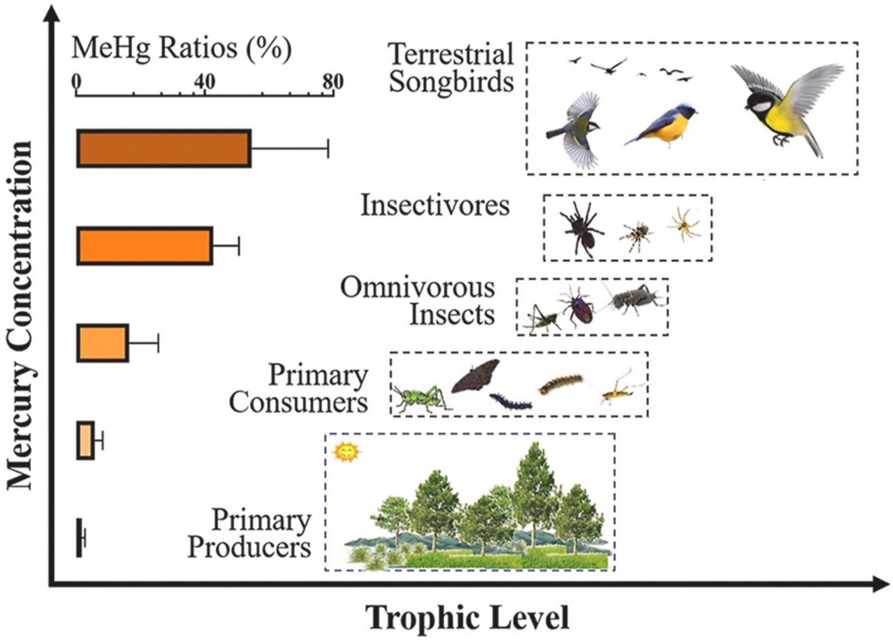

Figure 3: Schematic representation of the process of biomagnification in a sub-tropical montane forest food web, Southwest China (modified from Li et al. 2021).

The Minamata convention (2013) which allowed the establishment of mitigation measures regarding the Hg emissions came late despite the epidemic occurrence of the Minamata disease several decades before. Several reports from the Arctic Monitoring and Assessment Program (AMAP) and the UN Environment Programme (UNEP) investigated the emission and pollution at ground level of pollutants and are periodically reassessed nowadays.

The largest reductions in Hg emission were observed in Western Europe (Zhang et al. 2016) and led to a decline in atmospheric Hg concentration over the last decades (Berg et al. 2008). Moreover, Pacyna et al. (2016) also predicted further decreases in Hg deposition over the next decades. Despite regulations in Hg emissions, global anthropogenic emissions of Hg are still rising with an increase of 20% between 2010 and 2015 (UNEP 2019; AMAP 2021). Furthermore, climate change might impact Hg emissions as climate driven physical factors (e.g., temperature) can alter pollutant behaviors (Noyes et al. 2009, Basu et al. 2022; Chételat et al. 2022; Dietz et al. 2022; McKinney et al. 2022).

1.5 Biomonitoring and Tawny owls

Considering the deleterious health effects of Hg and the growing concern of its impact on the environment and biota, there is a pressing need to assess its concentration in the environment and the effects of mitigation measures. Measurements of chemical concentration can be made using dispersion modelling (known emission sources) and by field measurement of the pollution at ground level. The latter represents the impact of the pollutant on human health and the ecosystem and requires both temporal and/or spatial assessments (Wolterbeek 2002) through biological monitoring. Biomonitoring, defined as the act of assessing and observing ecosystems using physical parameters and chemical analyses (Bondaruk et al. 2015), is a vast field of study, and the use of a bioindicator species will depend on the purpose(s) of a study (Gerhardt 2002). Because of bioaccumulation and biomagnification, top predator species are more suitable for biomonitoring pollutants (Furness 1993; Burger et al. 2000).

Among birds, seabirds are often used for biomonitoring marine ecosystems (Verreault et al. 2008; Verboven et al. 2010; Erikstad et al. 2011: Celis et al. 2014; Tartu et al. 2015) as they are wide-ranging, ubiquitous, abundant, and common (Burger & Gochfeld 2004). However, most seabirds are migratory and will therefore reflect environmental pollution on a large spatial scale (i.e., breeding and wintering grounds), which may not be relevant on a local scale. On the contrary, sedentary birds reflect pollution on a local scale and are therefore more suitable to measure local changes in pollutant concentrations (Odjsö 1975; Dmowski 1999). Tawny owls (*Strix aluco*) are terrestrial raptors that are highly sedentary (Southern 1970) top predators (Galeotti 1994). The temporal trends of persistent organic pollutants (POPs) in Norway have been successfully investigated using Tawny owls (Bustnes et al. 2007). Bustnes et al. (2007) have shown organochlorine (OC) concentrations to drop by 74-96% over the 1986-2004 study period while brominated flame retardants (BFRs) decreased by 62%. Using the same population, POPs (Bustnes et al. 2011, 2015) and 39 essential and non-essential metals (Bustnes et al. 2013) were also investigated (between 1986-2009 and 1986-2005, respectively). Eleven of the 39 elements investigated showed a decline between 1986 and 2005. Therefore, tawny owls seem to be suitable biomonitors for local terrestrial environmental contamination and have in fact been several times successfully used as biomonitoring species (Ahrens et al. 2011; Carneiro et al. 2015; Eriksson et al. 2016; Grúz et al. 2019).

1.6 Eggs as a biomonitoring matrix in ecotoxicological studies

Through several biochemical and biological processes, the ingested pollutants are distributed to different tissues of the organism or are eliminated from the body via eggs, feathers, and excrements (Furness et al. 1986; Burger 1994; Dauwe et al. 2000, 2003; Eriksson et al. 2016; Grúz et al. 2019).

Previous studies have shown the importance of eggs in a Hg dose-dependent excretion in response to an increased dietary exposure to MeHg (Heinz 1976; March et al. 1983; Lewis and Furness 1993). Eggs can represent pollution in a short period prior to egg-laying (Furness 1993) and can be used as a reliable matrix for environmental biomonitoring of pollutants. However, maternal transfer to the egg can depend on both the trace metal studied (Agusa et al. 2005) as well as the studied species (Lewis et al. 1993; Agusa et al. 2005). Despite the variability in adult to egg transfer of Hg, Dittmann et al. (2012) presented four advantages for the use of eggs as a monitoring matrix: *i*) easy and cost-effective sampling, *ii*) detection of contaminants even in low environmental concentrations due to the effect of biomagnification, *iii*) low contaminant variability per site and species, and *iv*) allow a reliable interpretation of the results providing a well-known ecology of the species. Spatial and temporal trends have been found for OCs, Hg and selenium (Se) using Arctic seabird eggs (Braune et al. 2001, 2002). Waterbird and seabird eggs revealed inter- and intra-clutch differences in Hg contamination (Akaerok et al. 2010; Ackerman et al. 2016a).

Despite an increasing number of studies investigating Hg temporal trends (e.g., Lindqvist et al. 1991; Dietz et al. 2006; Rigét et al., 2007, 2011; Dittmann et al. 2012; Sun et al. 2019), the temporal trends of Hg concentration in biota appear difficult to assess. Namely, the above-mentioned studies reported discrepant temporal trends of Hg in biota, likely due to studying different species and using different statistical analyses. The challenge to investigate temporal trends of Hg is particularly noticeable in sub-Arctic terrestrial ecosystems as few studies are investigating these ecosystems and/or are using different species. Furthermore, factors that can influence Hg concentrations (e.g., diet, climate variables) may bias the results and their interpretations if not considered appropriately.

1.7 Variables affecting mercury concentrations

Bustnes et al. (2011) showed that the influence from climate variables as well as prey availability have an impact on POP concentrations in tawny owls. Moreover, foraging at different trophic levels led to variations in contaminant concentrations in two seabird colonies in the Canadian Arctic (Braune et al. 2015).

For the last decades, stable isotope analyses have increased as they have proven to be useful in characterizing food webs and dietary ecology (Inger & Bearhop 2008; Caut et al. 2009; Newsome et al. 2010; Boecken et al. 2011). Stable carbon isotope values ($\partial^{13}C$) reflect the carbon sources (i.e., habitat, ecoregion, or location (Layman et al. 2012)), while stable nitrogen isotopes ($\partial^{15}N$) allow to proxy the trophic position (Vander Zanden et al. 1997; Fry 2006; Layman et al. 2012). The combination of these two stable isotopes allows to investigate the contaminant burden in relation to the dietary ecology (e.g., Bond & Diamond 2009; Anderson et al. 2010; Lavoie et al. 2010; Carravieri et al. 2014; Bolton et al. 2017) and thus represents a means to study bioaccumulation and biomagnification of pollutants (Campbell et al. 2000; Borgå et al. 2004).

The bioavailability of pollutants in the ecosystem are directly (e.g., rising temperatures increase the uptake of toxicants; Lydy et al. 1999) or indirectly influenced (i.e., altered ecosystems by e.g., invasive species, over-harvesting, habitat destruction, and pathogens; Noyes et al. 2009) by climate variables. Several components (e.g., temperature, precipitation, and wind) characterized the climate variables and can be divided on a spatial and/or temporal scale.

Snow cover and temperature are important climate variables to investigate for owls in Northern Europe due to their direct impact on prey abundance (Halonen et al. 2007; Korpela et al. 2013). It is especially problematic with the ongoing climate change and rising temperatures (Korpela et al. 2013), in the vanguard of delayed winter snow, earlier snow melt, low snow depth and mild temperatures (fluctuating around 0°C) leading to ice formation (Aars & Ims 2002; Hörnfeldt 2004). Moreover, a density-independent mortality (i.e., mortality does not depend on the size or the density of a local group of individuals from the same taxon), and a weakened delayed density-dependent population regulation (number of individuals depends on the total population) can arise from these factors. It can last for several multi-annual cycles (Aars & Ims 2002; Hörnfeldt 2004; Bierman et al. 2006; Hipkiss et al. 2008). Bustnes et al. (2011) found that concentrations of POPs such as polychlorinated biphenyls (PCB) and 1,1-dichloro-2,2bis (p-chlorophenyl) ethylene (*p,p'*-DDE) were positively correlated with snow depth and negatively correlated with the North Atlantic Oscillation (NAO) only when the prey abundance was low. Polybrominated diphenyl ether (PBDE) concentrations, when prey abundance was good, were high for a low NAO and positively correlated with snow depth. In 2015, Bustnes et al. found that concentrations of perfluoro-octane sulfonate (PFOS) were negatively associated with temperature despite a complex interaction between temperature and feeding conditions: PFOS concentrations were higher when prey abundance was high and with low to medium temperature.

The NAO is used for large-scale climate variation and is often a better forecast variable for ecological processes than local climate variables (Stenseth et al. 2002). NAO is known for its influence on several physical factors (e.g., temperature, precipitation, and wind). The problem lies in the unpredictability of NAO variability (month-to-month or year-to-year) even if it is possible to assume a high or low NAO index (NAOI) for a certain season (Hurrell & Deser 2010). However, retrospective analyses are possible.

Global warming plays an important role in the variability of climate variables (and indirectly on diet). Global climate change is thought to alter physical factors, chemical and biological drivers (Noyes et al. 2009). Changes in the rate of precipitation and atmospheric moisture are to be expected because of the projected increase in surface temperature (Dore 2005). Temperature and precipitation are predicted to have the highest impact associated to global climate change (Noyes et al. 2009; Stern et al. 2012). For example, higher temperatures will enhance the toxicity of pollutants (e.g., Hg oxidation and atmospheric depletion events; Stern et al. 2012) while the increase of precipitation rates will enhance the surface airborne deposition. During the 20th century, precipitations in Europe have increased in the northern half of Europe, especially since 1950 (Dai et al. 1997; Dore 2005; IPCC 2021). This led to an increase in wet deposition of atmospheric contaminants (Noyes et al. 2009). The probability of precipitation and extreme events are very likely to intensify with global warming (IPCC 2021). On the contrary, lands which are getting drier will be subject to an increase of air pollution consecutive to the volatilization of certain pollutants (e.g., POPs; Noyes et al. 2009). Additionally, other important processes (e.g., snow melt, permafrost thawing, and carbon cycling) will potentially alter the fugacity, contaminant concentrations (MacDonald et al. 2002) and contaminants' toxicokinetics (i.e., absorption, distribution, metabolism, and excretion) increasing the chemical stress undergone by biota (Hooper et al. 2013). Moreover, with the modifications of the external environment, sensitivity to contaminants will increase for organisms reaching their physiological tolerance limits (Hooper et al. 2013).

Another impact of global climate change on the tawny owl's diet will be the reduction of prey abundance by e.g., alterations in trophic structures with the shifting of species limit range or the introduction of pathogens and/or invasive species (Noyes et al. 2009). Indeed, this reduction in the preferred prey can lead to a shift in dietary ecology and ultimately in trophic level at which the tawny owls are foraging. For example, Korpela et al. (2013) have shown the impact of mild winters on the abundance of mustelid species. Lower abundances of field voles, tawny owls' favorite prey, might force tawny owls to prey on passerine birds which are at a higher trophic position (Petty 1999; Solonen & Karhunen 2002) and have a higher load of pollutants.

1.8 Aims of the present study

Based on the observed decrease in atmospheric Hg concentrations, we expect a decline in Hg concentrations in wildlife. However, the predicted decline might be affected by climate variations and/or changes in food web structure and diet. Hence, the present study aimed to: *i*) investigate the temporal trends of Hg in tawny owl eggs collected between 1986 and 2019 in central Norway and to further investigate the Hg temporal trends observed between 1986 and 2005 by Bustnes et al. (2013) by comparing two different periods: 1986-2005 (referred to as first period) and 2006-2019 (referred to as second period), and *ii*) assess how the temporal trends of Hg are impacted by dietary ecological parameters (i.e., ∂^{13}C and ∂^{15}N) and by climate variability (i.e., NAO, max snow depth, and air temperature).

2 Material and methods

2.1 Study species

Geographically, Tawny owls (*Strix aluco*) are distributed all along the Palearctic Region. The Tawny owl is a long-lived, non-migratory and territorial species with a stable population of adult owls (Southern 1970; Hirons 1985; Galeotti 1994).

The Tawny owl is a generalist species feeding mainly on small rodents with field voles *Microtus agretis* being their preferred prey when their abundance is high (Petty 1999; Petty et al. 2000). When field vole abundance is low, owls feed on alternative prey species such as passerine birds (Petty 1999; Solonen & Karhunen 2002). The sampling was done at the tawny owl's northernmost distribution limit situated around 63°20'N (Figure 4; Sunde et al. 2001). In Central Norway, this species is mostly found in cultural landscapes (Sunde et al. 2001) where they are impacted by pesticides and other chemical products used for agricultural activities (Yoccoz et al. 2009).

As detailed by Sunde et al. (2001), the phenology of tawny owls can be divided in five periods throughout the year: *i*) late May to mid-August, the time between fledging and reaching independence; *ii*) from the independence or the death of the last offspring to the end of September; *iii*) between 1st October (late autumn – early winter) and the end of the year (31st December), which represents the more benign half of the winter; *iv*) the first trimester of the year (from 1st January to mid-March), the harsher part of the winter and; and *v*) between mid-March and late May, the pre-incubation time to the onset of the incubation (last weeks before the incubating period). The latter period takes place when temperatures rise again, and snow starts to melt. They reach maturity after one year and form a monogamous pair. Older pairs exhibit a higher success rate in breeding performance as older males deliver a higher mass of preys with higher frequency than younger ones. The ability to deliver other preys is of crucial importance when the availability of preferred prey is declining (Sasvári et al. 2000). Clutches usually contain two to three eggs (Southern 1970).

2.2 Field sampling

For more than 30 years (between 1986 and 2019), more than 100 tawny owl nest boxes have been deployed in the surroundings of Trondheim (Figure 4; 63.42°N 10.23°E) in Sør-Trøndelag, Central Norway (Bustnes et al. 2013). Nest boxes were visited twice a year: *i)* early April shortly after egg-laying to record the clutch size, and *ii*) during the first half of May to capture and weigh females, to ring the chicks and to collect non-hatching eggs. The number of eggs sampled per year varied from 1 (1990) to 23 (2004). No eggs were collected in 1988 and 2016 (Annex 1). The addled eggs (one per nest box) were placed in a polypropylene bag and were frozen shortly after sampling (Ahrens et al. 2011).

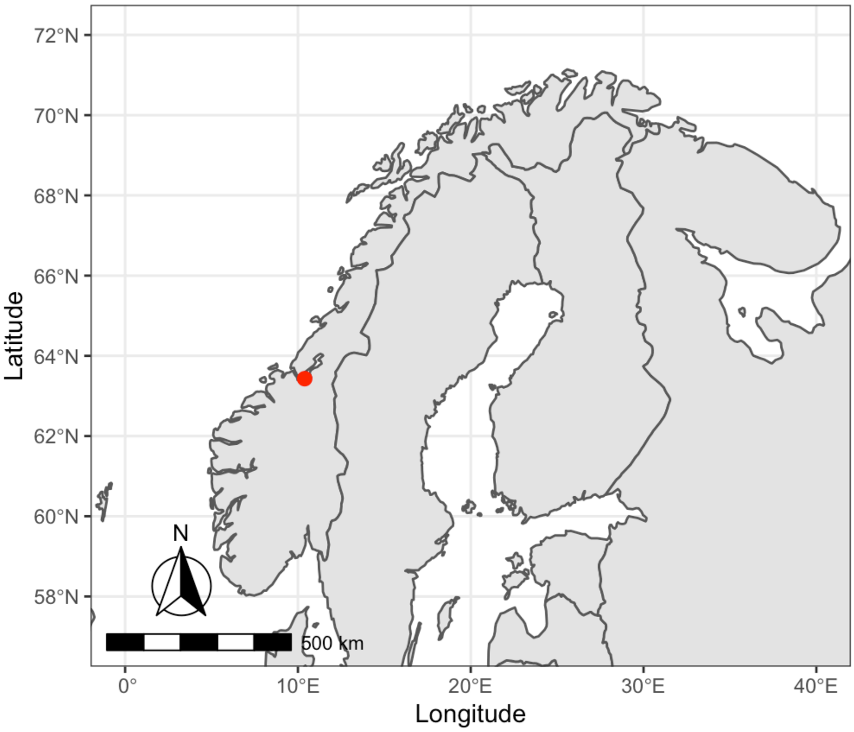

Figure 4: Map of the sampling location. The red dot represents the location of Trondheim (63.42°N, 10.23°E) in Sør-Trøndelag County, Central Norway, where the tawny owl eggs were collected betwenn 1986 and 2019.

2.3 Mercury analysis

The analysis for total mercury (THg, hereafter referred to as “Hg”) was performed on homogenized lyophilized egg subsamples using a Direct Mercury Analyser (DMA-80, Milestone, Italy) at the accredited Trace Element Laboratory at the Department of Ecoscience, Aarhus University (Denmark), following the US-EPA Method 7473 (US-EPA 1998). The analytical quality was controlled by concurrently analyzing aqueous standard solutions (10 ng and 100 ng Hg, prepared from 1000 ± 4 $mg.L^{-1}$ stock solution, Sigma-Aldrich, Switzerland), procedural blanks, duplicates, and Certified Reference Material (DORM-4; fish protein from the National Research Council, Canada; 0.412 ± 0.036 $\mu g.g^{-1}$ Hg dry weight, (*dw*). Measurements were subsequently corrected for instrumental drift using results from the aqueous 10 and 100 ng standards applied to the low- and high-concentration cell, respectively (drift was always < 10%). All samples were corrected for concurrent blanks (< 0.1 ng). The measured recovery percentage of DORM-4 was 101.4 ± 5.0% (mean ± *SD*; $n = 444$ during 2017-2021). The laboratory is accredited by the Danish Accreditation Fond DANAK following ISO 17025 for DMA-80 analysis of THg in biota with a detection limit of 0.001 $\mu g.g^{-1}$ *dw* and an extended measurement uncertainty (2**SD*) of 20%. As part of the laboratory QA/QC, the lab participates twice a year in the international laboratory performance study programme QUASIMEME (www.quasimeme.org), and has shown excellent long-term measurement accuracy and precision ($n = 15$ during 2017-2021; assigned concentration from 0.009 to 0.931 $\mu g.g^{-1}$ *dw*; *Z*-scores ranging between -1.0 and 0.7 with a mean of -0.1).

2.4 Stable isotope analysis

The analysis for stable carbon and nitrogen isotopes was carried out at the Stable Isotope Lab of the University of Koblenz-Landau (Germany). Ratios of stable carbon (^{13}C:^{12}C) and nitrogen (^{15}N:^{14}N) isotopes were determined in a homogenized lyophilized subsample (0.79 ± 0.16 mg) using a Flash 2000 HT elemental analyzer coupled via a ConFlo IV interface to a Delta V Advantage isotope ratio mass spectrometer (all Thermo Fisher Scientific, Bremen, Germany). Conventionally, the stable isotope values for carbon and nitrogen are expressed as ∂ values (‰) relative to their respective international measurement standards Vienna Pee De Belemnite and atmospheric N_2, respectively (Fry 2006). Internal reference material (casein) was measured concurrently in duplicate every ten samples, revealing an imprecision (± *SD*) ≤ 0.06‰ for both $\partial^{13}C$ and $\partial^{15}N$.

Depending on the type of soil, the preservation or mineralization of soil components with different stable carbon isotope values ($\partial^{13}C$), different soil will appear with varying ^{13}C concentrations (Fry 2006). Therefore, $\partial^{13}C$ is used to characterize the foraging source (Bond 2010). However, $\partial^{13}C$ presents higher concentrations during summer while fall and winter reverse this process (Fry 2006). When comparing seasons, $\partial^{13}C$ can be the cause of the variations so, to use the stable carbon isotope for temporal trends, it is primordial to compare the same season.

The stable nitrogen isotope value ($\partial^{15}N$) is preferably used because of its rather predictive trophic enrichment behavior (Kelly 2000). The excretion of ^{14}N being faster than the excretion of ^{15}N, ^{14}N leaves animals at a higher rate than ^{15}N. Therefore, as we climb the trophic food web, the ratio of the stable nitrogen isotope ($\partial^{15}N$) increases thus, it allows to approximate the trophic level (Fry, 2006). An average increase of approximatively 3–4‰ in isotopic ratio of nitrogen can be observed for the consumers (Vander Zanden & Rasmussen 2001; McCutchan 2003; Fry 2006; Caut et al. 2009). Yoshinaga et al. (1992) showed the importance of stable nitrogen isotope ($\partial^{15}N$) for the understanding of mercury circulation through food web. Marine and terrestrial food webs differ from each other, with marine food web being enriched in carbon and nitrogen (Peterson & Fry 1987; Kelly 2000; Bond 2010).

2.5 Climate variables

In the present study, three climate components, i.e., NAO, air temperature (hereafter referred as "temperature"), and maximum snow depth (hereafter referred as "max snow depth"), were selected to further explore their previously suggested value in studying climate forcing on contaminant exposure (Bustnes et al. 2011, 2015).

Lamb & Peppler (1987) defined the NAO as an alternation of atmospheric mass stretching from the Azores region high surface pressure (i.e., subtropical climate) to the East of Greenland low surface pressure (i.e., subpolar climate). The state of the NAO determines the direction and speed of the midaltitude westerlies across the North Atlantic Ocean in relation to pressure gradients. Although it is more noticeable during winter, it remains the dominant mode of atmospheric circulation in the North Atlantic Ocean all year round (Dickson et al. 2000; Visbeck et al. 2001). Additionally, the NAO affects the ocean through changes in heat content, gyre circulations, mixed layer depths, salinity, and formation of deep water in high latitudes (Hurrell & Deser 2010) as well as the pollutant transport on a hemispheric scale (Eckhardt et al. 2003; Travnikov 2012). The NAOI is the numerical representation of the varying strength of the two recurring pressure patterns in the North Atlantic sector. This index varies around the zero-value where *i*) a positive NAOI value represents a large pressure difference between the two regions mentioned above, indicating warm conditions in northeastern North America, East and Northern Europe with increase probability of storm events and precipitation, and cold conditions across southern Europe; and *ii*) a negative NAOI value represents a weak pressure difference between the Azores and East Greenland, with opposite conditions as just outlined (Wanner et al. 2001).

The data for the NAOI (Dec-March) were collected on the web pages of Jim Hurrell at the National Centre for Atmospheric Research (NCAR). Data on temperature (Annex 4) and max snow depth (Annex 5) were collected from the seklima web pages of the Norwegian Meteorological Institute. A total of 16 meteorologic stations were selected to represent the sampling area (Bustnes et al. 2013) for the maximum snow depth. Means of the temperature and the snow depth have been calculated for each winter period (Dec-March) except for 1988 and 2016 when no eggs were collected. Not all the stations provided data for snow depth for each month of each year, but enough data were gathered to establish a mean maximum snow depth for the total study period. Only one station provided all the values of the temperature for the study period and was thus, used to collect the temperature data (Værnes – Trondheim airport; Bustnes et al. 2011). Moreover, temperature is more spatially synchronized than variation in snow depth thus, it will not affect the comparison (Bustnes et al. 2011). Some discrepancies can be observed between the temperature data used by Bustnes et al. (2011, 2015) and the data used for the current study. Those discrepancies are imputed to a longer winter period (Dec-March) chosen for the current study compared to the previous one by Bustnes et al. (2011) (i.e., Jan-March). Indeed, as the data for the winter NAOI covered four months in Bustnes et al. (2011) (i.e., Dec-March), it is more relevant to have data for the temperature for the same period. The difference for the max snow depth is because different meteorological stations were selected as no station had data for the entire period and to cover the entire sampling area.

2.6 Statistical analysis

All statistical analyses were performed using R (version 4.1.2; R Core Team 2021) and RStudio (version 2021.09.1+372). The significance level was set to *alpha* = 0.05. To avoid type I (rejecting the null-hypothesis while true) and type II errors (not rejecting the null-hypothesis while false) all data were explored to satisfy the modeling requirements (Zuur et al. 2010).

The possible presence of outliers was investigated using boxplots and dotcharts. While no outliers were observed for Hg concentrations (*dw*; hereafter referred as “HgDw”), two outliers were identified for ∂^{13}C and ∂^{15}N (-101.66‰ and 29.92‰, respectively) and were therefore removed from all statistical analyses. Missing data (N/A) were also removed (Annex 1) without affecting the dataset (i.e., individuals with no paired values for HgDw and stable isotopes). To explore the homogeneity of variances, linear models were fitted, and subsequently, residual values of each variable were plotted against fitted values. No patterns were observed for residuals *versus* fitted value plots, scale-location plots, and Cook’s distance plots.

To verify if the data showed a normal distribution, histograms and Q-Q plots were visually explored and Shapiro-Wilk tests were run. HgDw did not show a normal distribution ($W = 0.89$, $p < 0.01$) and were subsequently *ln* transformed. Finally, we investigated collinearity among covariates using Variation Inflation Factors (VIFs). As stated in Zuur et al. (2010), even parameters with a VIF of 2 may be collinear. In the current data exploration, none of the different variables were observed with a VIF lower than 2 although some variables had a VIF close to 2. Nonetheless, we concluded no collinearities were present.

Furthermore, we investigated the independence of variables by evaluating temporal autocorrelation using time series plots (stats package; Venables & Ripley 2002) as well as autocorrelation (ACFs) and partial autocorrelation functions (PACFs; stats package; Venables & Ripley 2002). Time series are used to see how an object (i.e., a data frame) behaves over a period of defined time. Time series plots (Annex 14) did not show any seasonal or cyclic patterns nor any additive or multiplicative trends for the investigated variables (i.e., temperature, max snow depth, NAOI, HgDw, ∂^{13}C and ∂^{15}N). However, a sudden shift was observed for HgDw between 2000 and 2005 and will be further investigated. ACFs, also referred to as lagged correlations, are used to investigate the correlation between a time series and its lagged values. PACFs are similar to ACFs and explain the partial correlation between a time series and its lags. No lags were observed outside the threshold levels for the temperature, max snow depth, NAOI and HgDw from both ACF and PACF plots (Annex 15). Therefore, no correlations were observed, and we concluded that the values were independent. For ∂^{13}C, lags were observed outside the threshold values for the ACF plot (Annex 16) and a tail-off was observed on the PACF plot. We concluded on a moving average model (MA) with a value at a given time that depends on the three previous ones (cut off on the ACF plot after the third lag). A tail-off was also observed for ∂^{15}N on the PACF plot (Annex 16) and, therefore, we concluded here also to use a MA. A cut off was observed after the first lag on the ACF plot thus, a value of ∂^{15}N at a given time depends on the previous value. In conclusion, the values of ∂^{13}C and ∂^{15}N are not independent as they depend respectively on their three previous values and the previous value.

As just mentioned above, we observed a sudden shift in HgDw between 2000-2005 where concentrations seemed higher prior to 2005. To further investigate this sudden shift, two different periods (1986-2005 and 2006-2019) were investigated for potential differences in HgDw levels. Moreover, the delineation of this first period allows for a direct comparison and discussion of results presented in the previous study by Bustnes et al. (2013). This study reported namely on the temporal trend of Hg in the same owl population but by using feathers as matrix. Subsequently, an ANOVA test was performed to investigate if a mean HgDw for a specific year differed from the others. If no means differed from one another, it meant that the HgDw was identical throughout the study period (1986-2019), and that the sudden shift observed in time series plots cannot be considered significant.

We further investigated possible collinearity among covariates using Pearson correlation matrices (correlation package; Makowski et al. 2019). Three correlation matrices were created and corresponded to the entire study period (1986-2019; Annex 7), and to the two defined periods (1986-2005 and 2006-2019; respectively in Annexes 8 and 9). Over the entire study period, negative correlations between year and *ln*-transformed HgDw (hereafter referred to as *ln*(HgDw)), between temperature and max snow depth were observed, and between temperature and *ln*(HgDw). Temperature and NAOI, and ∂^{13}C and *ln*(HgDw) were positively correlated. For the period 1986-2005, negative correlations were found between year and temperature, between year and NAOI, between year and $\partial^{13}C$, and between temperature and *ln*(HgDw). Positive correlations were found between temperature and NAOI, and between $\partial^{13}C$ and *ln*(HgDw). For the second period 2005-2019, year and $\partial^{15}N$, and temperature and NAOI were positively correlated. Negative correlations were found between temperature and max snow depth, and between max snow depth and NAOI. Therefore, to avoid a loss in statistical power, temperature and max snow depth, and temperature and NAOI were not placed in the same candidate models for the entire study period (1986-2019). For the first period (1986-2005), temperature and NAOI were not placed in the same candidate model. For the second period (2006-2019), temperature and NAOI, temperature and max snow depth, and max snow depth and NAOI were not placed in the same candidate models Scatterplots were also created to further support the investigation of collinearity (Annex 14).

To assess the temporal trends of mercury between 1986-2019 and the two different periods (1986-2005 and 2006-2019), generalized additive models (GAMs) were fitted using the mgcv package (Wood 2006). Additionally, linear models (LMs) were fitted to test which relationships (i.e., linear, or non-linear) fitted best by using ANOVA tests (Chi square tests). The explanatory variables were smoothed using splines and were designed to detect trends in the presence of noisy data. To investigate the temporal trends of the explanatory variables thought to influence HgDw (i.e., temperature, max snow depth, NAOI, $\partial^{13}C$ and $\partial^{15}N$), partial residuals from a single explanatory variable were plotted against the year (i.e., explanatory variable ~ Year). Furthermore, to investigate how *ln*(HgDw) varied in presence of a single explanatory variable, partial residuals from a single explanatory variable were plotted against each predictor (i.e., *ln*(HgDw)~ explanatory variable).

Eighteen models were defined for the entire period and the two different periods (respectively, Table 5; Annexes 12 and 13) to describe the relationships between the response (*ln*(HgDw)) and explanatory variables (i.e., temperature, max snow depth, NAOI, $\partial^{13}C$, and $\partial^{15}N$), and to assess their linearity. These eighteen models were defined while accounting for the correlation found between variables during the data exploration. The first candidate model defined composed solely of the temporal variable (i.e., year) as explanatory variable. The temporal variable was kept in all subsequent candidate models. Five models were defined to investigate how each temporal variation of the explanatory variables influenced the *ln*(HgDw). As aforementioned, we found that the dietary ecological parameter values (i.e., $\partial^{13}C$ and $\partial^{15}N$) were not independent and, therefore, the temporal variations of each dietary ecological parameter were investigated. For all candidate models using dietary ecological parameters, the two stable isotope values were not placed in the same candidate model as they are used as proxy to describe two different modalities of the dietary ecology. The dietary ecological variables were found to be temporally autocorrelated to one another, hence we were interested to investigate the influence of the temporal variability of each stable isotope value and the climate variables on *ln*(HgDw). Furthermore, climate variables may influence the dietary ecology (e.g., carbon source and trophic position) therefore, the possible interaction between the stable isotope values and the climate variables in addition with the temporal variable was tested. Temperature was found to be correlated with max snow depth and with NAOI. Furthermore, a correlation between max snow depth and NAOI was found for the second period and, therefore, only one climate variable was used in each candidate models.

The interaction between covariates were smoothed using tensor product interaction bases `ti()`. Thin plate splines (weighted basic functions) were used as they are better suited for multiple covariate modelling (assess covariate interactions). We resampled a linear model using the REML function (`mosaic` package; Prium et al. 2017) to investigate the complexity of the different GAMs. The complexity or smoothness of the model, described by the effective degree of freedom (*edf*), was limited by k (set to 4; Wood 2006; Bustnes et al. 2013) and gamma (γ) was set at 1.4 (Bustnes et al. 2013) to increase the smoothing effect by multiplying each *edf* and to avoid over-fitting (Wood 2006). The candidate models were ranked using Akaike's Information Criterion corrected for small sample sizes (AIC_c) using `MuMIn` package (Burnham & Anderson 2002). The most parsimonious model was selected among the models with $\Delta AIC_c \leq 2.00$ while at the same time exhibiting the highest AIC_c weight (AIC_cWt).

3 Results

3.1 Descriptive statistics

The full dataset used for the statistical analysis is shown in Annex 1 and descriptive statistics for the entire study period as well as for the two defined shorter periods (first period: 1986-2005; second period: 2006-2019) are presented in Table 1.

Mean HgDw for the first period (1986-2005: 0.12 ± 0.07 $\mu g\ g^{-1}$) was significantly higher ($t = 6.16$, $p < 0.01$) compared to the second period (2006-2019: 0.07 ± 0.04 $\mu g\ g^{-1}$), supporting the observed sudden shift in the HgDw time series (Annex 15). Mean winter air temperature (hereafter referred to as T), max snow depth (hereafter referred to as MS) and NAOI for the two periods were however not statistically different (all $t \leq 0.64$; all $p \geq 0.11$). A significant difference between the two periods was however observed for $\partial^{13}C$ ($t = 7.04$; $p < 0.01$), showing lower $\partial^{13}C$ values for the second period (-28.76 ± 0.88 ‰). In contrast, no significant difference was observed for $\partial^{15}N$ values of the two periods ($t = 0.77$; $p = 0.43$).

Table 1: Descriptive statistics for Tawny owl egg Hg concentrations as well as the dietary ecological parameters ($\partial^{13}C$ and $\partial^{15}N$) and environmental variables (temperature, max snow depth and North Atlantic Oscillation) for the entire study period as well as the two shorter periods. HgDw: dry weight mercury concentration; HgWw: wet weight mercury concentration; T: mean winter air temperature; MS: max snow depth; NAOI: North Atlantic Oscillation index; $\partial^{13}C$: stable carbon isotope value; $\partial^{15}N$: stable nitrogen istoope value; N: number of eggs.

Variables			**Mean**	**SD**	**Median**	**Maximum**	**Minimum**
	Period	***n***					
HgDw ($\mu g\ g^{-1}$)	1986-2019	224	0.10	0.06	0.08	0.46	0.01
	1986-2005	141	0.12	0.07	0.11	0.46	0.01
	2006-2019	83	0.07	0.03	0.06	0.19	0.01
HgWw ($\mu g\ g^{-1}$)	1986-2019	224	0.02	0.01	0.01	0.08	0.00
	1986-2005	141	0.02	0.01	0.02	0.08	0.00
	2006-2019	83	0.01	0.00	0.01	0.04	0.00
T (°C)	1986-2019	224	-0.37	1.68	-0.10	2.62	-4.12
	1986-2005	141	-0.31	1.58	-0.10	2.62	-4.02
	2006-2019	83	-0.47	1.85	-0.30	2.27	-4.125
MS (cm)	1986-2019	224	63.39	16.20	61.93	105.08	28.12
	1986-2005	141	62.26	16.95	60.61	105.08	28.12
	2006-2019	83	65.71	14.68	64.44	83.27	36.71
NAOI	1986-2019	224	0.54	1.13	0.72	2.97	-2.90

	1986-2005	141	0.44	0.98	0.00	2.32	-1.82
	2006-2019	83	0.69	1.35	0.80	2.97	-2.90
∂^{13}C (‰)	1986-2019	224	-28.16	1.13	-28.16	-25.11	-31.07
	1986-2005	141	-27.81	1.12	-27.88	-25.11	-30.36
	2006-2019	83	-28.76	0.88	-28.78	-26.73	-31.07
∂^{15}N (‰)	1986-2019	224	+7.39	+1.45	+7.46	+10.82	+1.39
	1986-2005	141	+7.35	+1.46	+7.42	+10.82	+3.86
	2006-2019	83	+7.19	+1.43	+7.56	+10.07	+1.39

As we found significant differences in mean HgDw between the two shorter periods, inter-annual differences in HgDw during the entire study period were further investigated using an ANOVA test. Significant inter-annual differences in HgDw ($F = 4.80$; $p < 0.01$) were found and *a posteriori* Tukey HSD pairwise comparisons are presented in Annex 11. Mainly, the years 1989, 2005 and 2014 appeared to present the lowest HgDw. In accordance with the HgDw time series plot (Annex 15), the years 2000, 2002, and 2003 were found to show significantly higher HgDw levels than in 2005.

3.2 Temporal trends of mercury

While GAMs were predominantly used throughout the entire current study, a linear model was used to investigate the annual HgDw change. A significant yearly decrease in HgDw of -2.40 % was found ($F = 29.38$; $p < 0.01$). The partial residuals for *ln*(HgDw) from a GAM (*ln*(HgDw) ~ Year) were plotted to visualize the temporal changes over the entire study period (Figure 5c) and a non-linear relationship was observed ($edf = 2.77$; $R^2_{adj} = 0.14$). For the period 1986 to 2005, no significant linear temporal change in HgDw can be observed ($t = -1.70$; $p = 0.09$) but rather a non-linear time series ($edf = 2.77$; $R^2_{adj} = 0.10$; Figure 5a). We observed a small decrease in mercury concentrations from 1986 to approximately 1991, after which HgDw rose again until 1999 and was followed by another decrease. No significant linear trend in HgDw was observed between 2006 and 2019 ($t = -0.27$; $p = 0.78$). However, again, a non-linear trend was found ($edf = 2.82$; $R^2_{adj} = 0.09$; Figure 5b). HgDw concentrations rose until approximately 2010, decreased until 2015 and increased again after 2015.

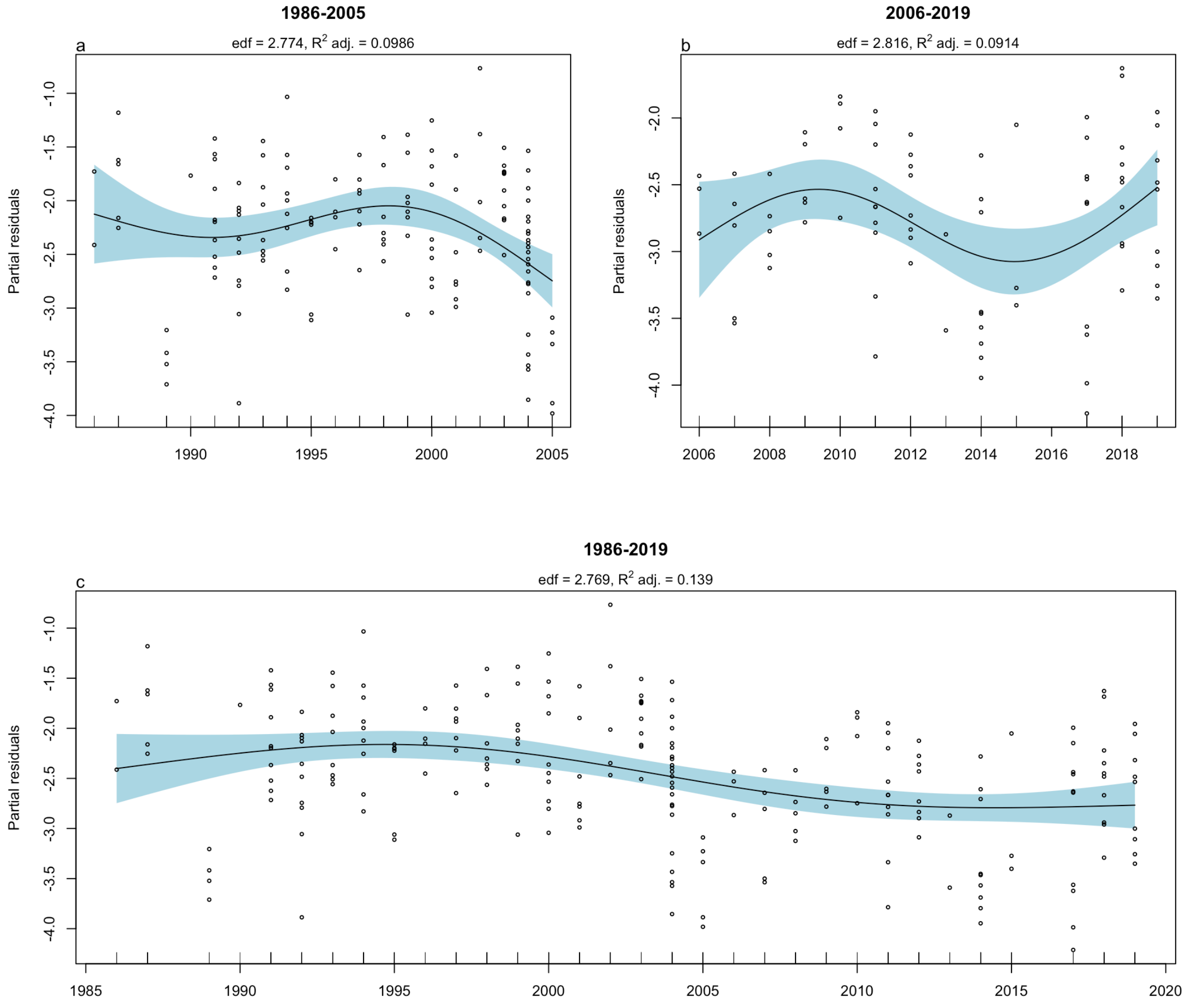

Figure 5: Annual variations in partial residuals for *ln*-transformed HgDw for the two periods: (a) 1986-2005, and (b) 2006-2019, and for the entire period (c).

3.3 Temporal variability of the predictors

GAMs were fitted to investigate temporal variation in the explanatory variables (i.e., T, MS, NAOI, ∂^{13}C and ∂^{15}N) over the entire study period (Figure 6). Moreover, GAMs were fitted without the smooth function to allow comparison with a potential linear trend. These two model relationships (i.e., linear and non-linear) were compared using an ANOVA (Chi square test) to assess the best fit (Table 2).

Table 2: ANOVA outputs using Chi square test and generalized additive model summary. Comparisons between linear regressions and non-linear regressions to investigate the temporal variation of the predictor variables, i.e., temperature, max snow depth, North Atlantic Oscillation index, $\partial^{13}C$, and $\partial^{15}N$. *Edf*: effective degree of freedom for each predictor of the model; k': the number of splines used for each predictor of the model; R^2_{adj}: R^2 adjusted.

Response variable	**Explanatory variable**	**Pr (> Chi)**	**Linear/Non-linear**	***edf***	**k'**	R^2_{adj}
Temperature	Year	< 0.01	Non-linear	1.00	3	-0.00
Max snow depth	Year	< 0.01	Non-linear	1.00	3	0.00
NAOI	Year	< 0.01	Non-linear	2.60	3.0	0.09
$\partial^{13}C$	Year	< 0.01	Non-linear	2.81	3.00	0.24
$\partial^{15}N$	Year	< 0.05	Non-linear	2.49	3.0	0.08

An essentially linear and increasing trend in T was however observed (*edf* = 1.00; $R^2_{adj} = -0.00$; Figure 6a). A slight increase in MS was observed over the entire study period (*edf* = 1.00; $R^2_{adj} = 0.01$; Figure 6b), despite no statistical difference was observed between the two study periods (t = -1.60; p = 0.11). A non-linear trend was observed for NAOI (*edf* = 2.65; $R^2_{adj} = 0.09$). The NAOI decreased between 1986 and approximately 2005 and increased again after 2006 (Figure 6c). However, no significant difference (t = -1.47; p = 0.14) was found between the first (1986-2005) and the second period (2006-2019). For $\partial^{13}C$, a non-linear trend was observed (*edf* = 2.90; $R^2_{adj} = 0.24$) showing a small increase at the beginning of the study period (1986-1995), followed by a decrease from 1995 to 2011 and a final increase (Figure 6d). A non-linear trend was observed for $\partial^{15}N$ as well (*edf* = 2.41; $R^2_{adj.} = 0.08$; Figure 6e) with a small decrease observed from 1986 to 2005 and an increase from 2006 to reach approximatively the original value from 1986. However, no statistical difference (t = 0.77; p = 0.43) in mean $\partial^{15}N$ values could be observed between the two study periods.

3.4 Influence of the predictors on the mercury concentrations

Linear regressions were compared to non-linear ones using Chi-square tests to assess which fit better explained the observed temporal trend of Hg under the influence of the predictors. For most of the selected models, non-linear regressions were found to present the best fit (Table 3). For four out of 18 candidate models a linear regression was observed to present the best fit (i.e., Year + $\partial^{13}C$, Year + NAOI * $\partial^{13}C$, Y + MS + $\partial^{13}C$, and Year + MS * $\partial^{13}C$). For these models, GAMs showed *edf* close to 1.00, indicative of linear trends. Nonetheless, the GAM procedure was retained rather than using a LM procedure to make sure the methodology remained comparable among the different models.

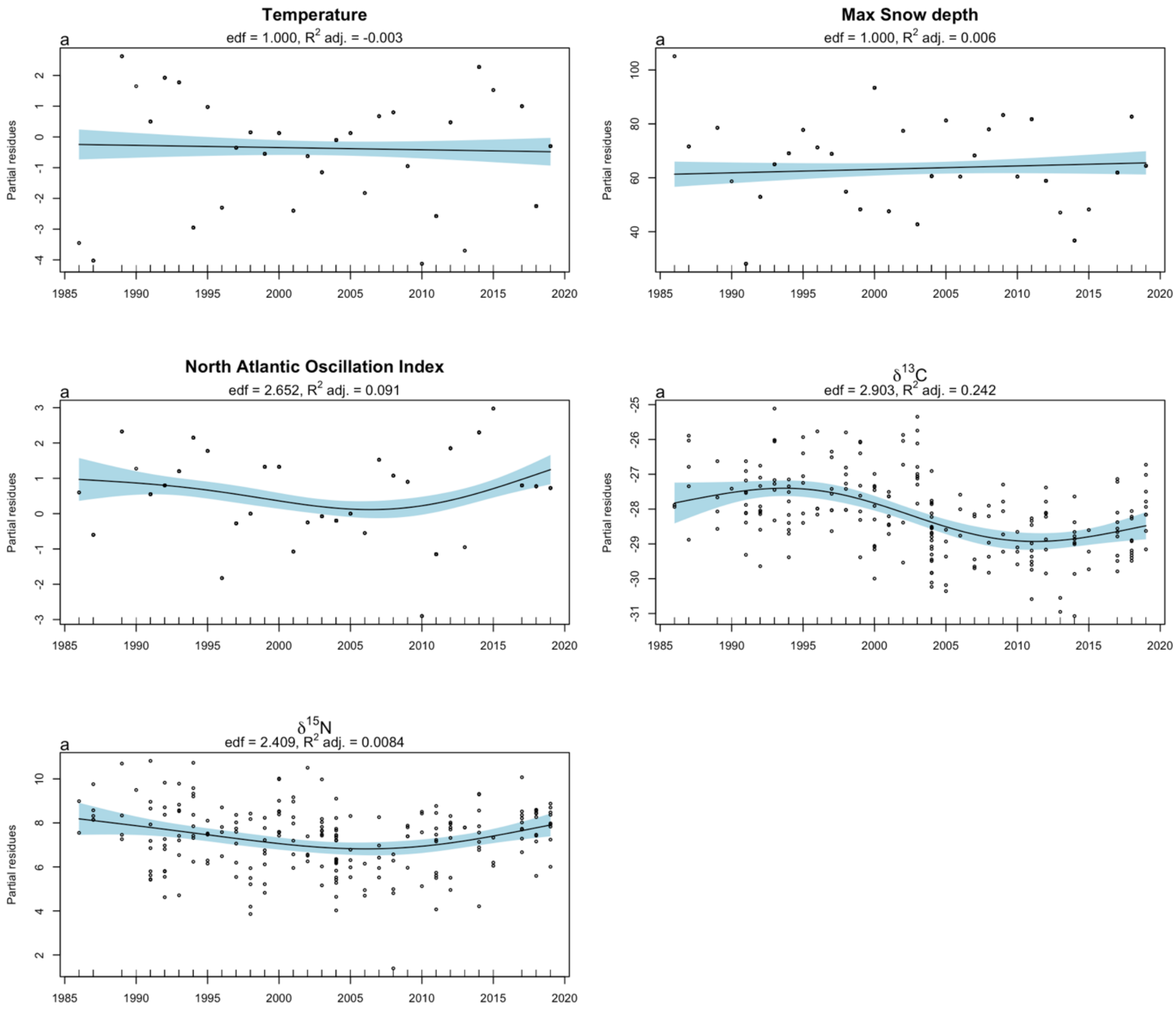

Figure 6: Partial residuals (GAMs) for the annual variations of the different climate variables and dietary ecology parameters thought to influence the temporal trends of Hg.

Table 3: ANOVA outputs using Chi square test and generalized additive model summary. Comparisons between linear regressions and non-linear regressions for the different candidate models. Linear/Non-linear stands for which regression fitted best for the tested model; *edf*: effective degree of freedom for each predictor of the model; k': the number of splines used for each predictor of the model; R^2_{adj}: R^2 adjusted. *Edf* and k' were sorted as described by the predictor. Y: year; T: temperature; MS: max snow depth; NAOI: North Atlantic Oscillation index.

Models	**Pr (> Chi)**	**Linear/Non-linear**	**Predictor**	***edf***	**k'**	**R^2_{adj}**
Y	< 0.05	Non-linear	Y	1.0	3	0.11
Y + ∂^{13}C	0.24	Linear	Y	1.20	3	0.23
			∂^{13}C	1.00	3	
Y + ∂^{15}N	< 0.05	Non-linear	Y	1.00	3	0.11
			∂^{15}N	1.00	3	
Y + T	< 0.01	Non-linear	Y	2.36	3	0.25
			T	2.23	3	
Y + MS	< 0.05	Non-linear	Y	1.00	3	0.10
			MS	1.00	3	
Y + NAOI	< 0.01	Non-linear	Y	2.65	3	0.16
			NAOI	1.00	3	
Y + T + ∂^{13}C	< 0.05	Non-linear	Y	1.00	3	0.34
			T	2.12	3	
			∂^{13}C	1.00	3	
Y + T * ∂^{13}C	< 0.01	Non-linear	Y	1.00	3	0.34
			T	2.18	3	
			∂^{13}C	1.00	9	
			T * ∂^{13}C	1.28	3	
Y + T + ∂^{15}N	< 0.01	Non-linear	Y	2.54	3	0.25
			T	2.15	3	
			∂^{15}N	1.00	3	
Y + T * ∂^{15}N	< 0.01	Non-linear	Y	2.51	3	0.25
			T	2.14	3	
			∂^{15}N	1.00	9	
			T * ∂^{15}N	1.35	3	
Y + NAOI + ∂^{13}C	< 0.01	Non-linear	Y	1.00	3	0.25
			NAOI	1.00	3	
			∂^{13}C	1.00	3	
Y + NAOI * ∂^{13}C	0.21	Linear	Y	1.00	3	0.26
			NAOI	1.00	3	
			∂^{13}C	1.00	9	
			NAOI * ∂^{13}C	1.50	3	
Y + NAOI + ∂^{15}N	< 0.01	Non-linear	Y	2.67	3	0.16
			NAOI	1.00	3	
			∂^{15}N	1.00	3	
Y + NAOI * ∂^{15}N	< 0.01	Non-linear	Y	2.64	3	0.18
			NAOI	1.00	3	
			∂^{15}N	1.00	9	

			NAOI * ∂^{15}N	2.48	3	
Y + MS + ∂^{13}C	0.24	Linear	Y	1.21	3	0.23
			MS	1.00	3	
			∂^{13}C	1.00	3	
Y + MS * ∂^{13}C	0.15	Linear	Y	1.00	3	0.24
			MS	1.00	3	
			∂^{13}C	1.00	9	
			MS * ∂^{13}C	1.71	3	
Y + MS + ∂^{15}N	< 0.05	Non-linear	Y	1.00	3	0.10
			MS	1.00	3	
			∂^{15}N	1.00	3	
Y + MS * ∂^{15}N	< 0.05	Non-linear	Y	2.36	3	0.13
			MS	1.00	3	
			∂^{15}N	1.00	9	
			MS * ∂^{15}N	1.00	3	

For the entire study period, two candidate models showed $\Delta AIC_c \leq 2.00$ (Table 4): *i)* Y + T * ∂^{13}C ($\Delta AICc = 0.00$), and *ii*) Y + T + ∂^{13}C ($\Delta AICc = 0.33$). The latter was chosen as the most parsimonious model due to having the lowest number of parameters ($k = 5$) and highest *AICcWt*. This model explained 35.50% of the deviance and its partial residuals were plotted in Figure 7. The models selected for the first (1986-2005) and second period (2006-2019) are presented in Annex 12 and 13, respectively.

Table 4: Selection among eighteen different candidate Generalized Additive Models explaining the annual variation of the ln-transformed Hg concentrations (*dw*) in tawny owl eggs between 1986 and 2019. Y: year; T: temperature (°C); MS: max snow depth (cm); NAOI: North Atlantic Oscillation index; ∂^{13}C: carbon isotopic ratio; ∂^{15}N: nitrogen isotopic ratio; *GCV*: generalized cross-validation; AIC_c: Akaike's Information Criterion corrected for small sample size; AIC_cWt: AICc weight; *Cum.Wt*: cumulated weight.

Models	***GCV***	R^2_{adj}	***Deviance***	AIC_c	ΔAIC_c	AIC_cWt	***Cum.Wt***
Y + T * ∂^{13}C	0.28	0.34	0.36	352.56	0.00	0.27	0.99
Y + T + ∂^{13}C	0.28	0.34	0.35	352.88	0.32	0.36	0.72
Y + NAOI + ∂^{13}C	0.31	0.25	0.26	378.79	26.23	0.00	0.00
Y + NAOI * ∂^{13}C	0.32	0.26	0.27	379.81	27.24	0.00	0.00
Y + T + ∂^{15}N	0.32	0.26	0.27	381.37	28.81	0.00	0.00
Y + T	0.32	0.25	0.26	382.16	29.60	0.00	0.00
Y + T * ∂^{15}N	0.32	0.25	0.28	383.32	30.76	0.00	0.00
Y + MS * ∂^{13}C	0.32	0.24	0.26	384.71	32.15	0.00	0.00
Y + ∂^{13}C	0.32	0.23	0.24	385.79	33.23	0.00	0.00

Y + MS + ∂^{13}C	0.33	0.23	0.24	387.42	34.86	0.00	0.00
Y + NAOI	0.360	0.16	0.18	405.20	52.64	0.00	0.00
Y + NAOI * ∂^{15}N	0.36	0.18	0.20	405.26	52.70	0.00	0.00
Y + NAOI + ∂^{15}N	0.36	0.17	0.18	406.22	53.66	0.00	0.00
Y + d15N	0.37	0.13	0.15	413.11	60.55	0.00	0.00
Y	0.37	0.13	0.15	414.10	61.54	0.00	0.00
Y + MS	0.37	0.13	0.15	414.13	61.57	0.00	0.00
Y + MS * ∂^{15}N	0.37	0.14	0.16	414.56	62.00	0.00	0.00
Y + MS + ∂^{15}N	0.37	0.13	0.15	415.08	62.52	0.00	0.00

For the first period, the highest ranked candidate model composed Y + T * ∂^{13}C, being the only model with $\Delta AIC_c \leq 2.00$ (deviance = 0.22). The runner up candidate model composed Y + T + ∂^{13}C and had $\Delta AIC_c = 2.00$ (deviance = 0.22). Despite the latter model presenting higher AIC_c, it was chosen as the most parsimonious model to better compare the first study period to the entire one (Figure 8).

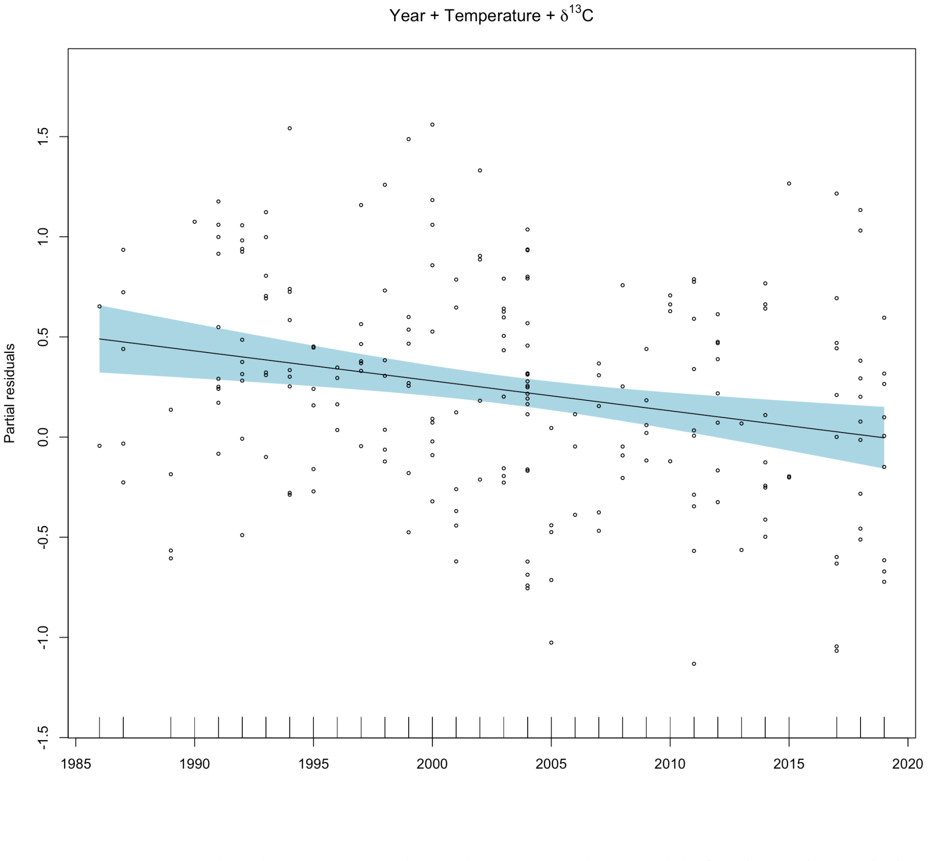
Year + Temperature + δ^{13}C

***Figure** 7: Most parsimonious model chosen among the eighteen candidate models* for the entire period (1986-2019)*. The partial residuals of the ln-transformed HgDw were plotted against the sampling year (*R^2_{adj} *= 0.34; deviance = 0.36).*

For the second study period (2005-2019), the highest ranked candidate model composed Y + T + $\partial^{13}C$ (deviance = 0.22) followed by a model composing Y + T * $\partial^{15}N$ ($\Delta AIC_c = 1.47$; deviance = 0.33). While the explained deviance of the former is lower than the latter, the most parsimonious model was identified to be the latter to allow for comparison with the other study periods (Figure 9). Despite finding no linear trends in HgDw for the first period (1986-2005) when not taking any covariates into account, we observed a slight decreasing non-linear trend in HgDw during the first period because of the influence of the T and the $\partial^{13}C$ (Figure 8). No linear trends were found for the second period (Figure 9) despite the influence of the T and $\partial^{13}C$. Over the entire period, notwithstanding that no linear trends were found in the second period, an essentially linear decreasing trend was observed (Figure 7).

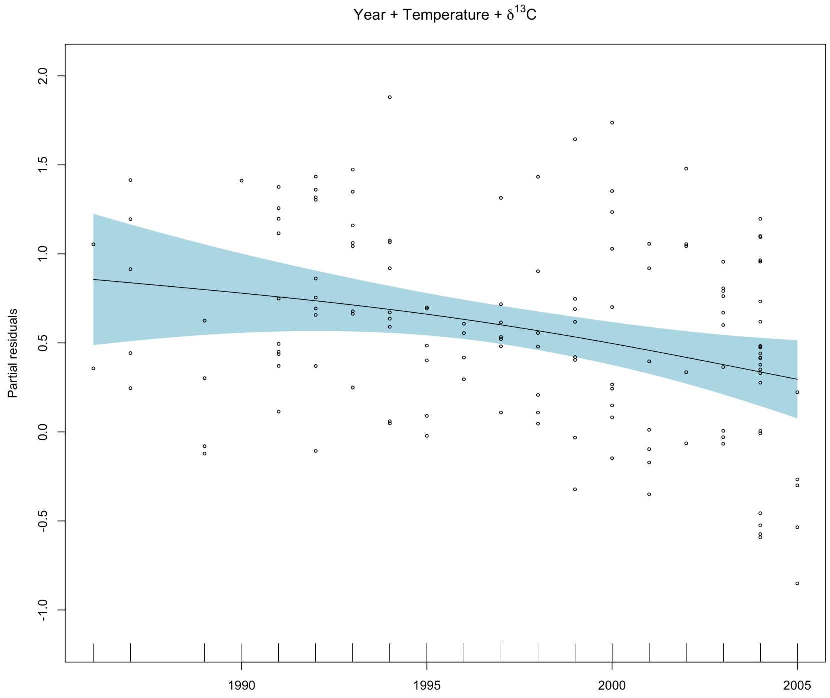

***Figure 8*:** Most parsimonious model chosen among the eighteen candidate models for the first period (1986-2005). The partial residuals of the *ln*-transformed HgDw were plotted against the sampling year ($R^2_{adj} = 0.312$, explained deviance = 0.217).

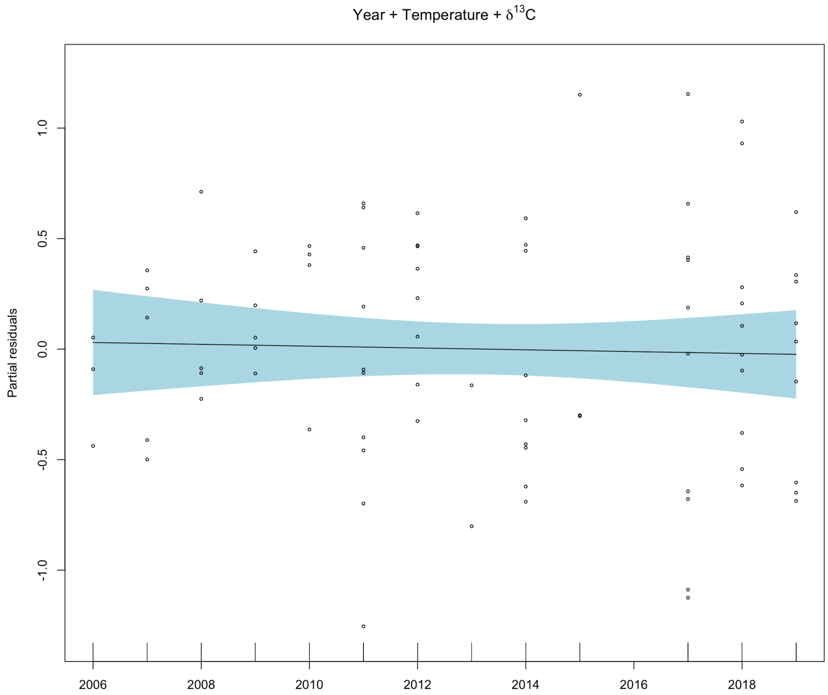

Figure 9: Most parsimonious model chosen among the eighteen candidate models for the second period (2006-2019). The partial residuals of the *ln*-transformed HgDw were plotted against the sampling year (R^2 adj. = 0.188, explained deviance = 0.217).

4 Discussion

The main objective of the present study was to investigate the temporal trends in Hg concentrations in tawny owl eggs between 1986 and 2019, and to investigate the possible influence of dietary ecological parameters (stable isotopes) and climate variables on Hg concentrations. Two different periods (1986-2005 and 2006-2019) were also investigated to provide complementary information regarding an observed shift in Hg concentrations during the data exploration. The first period (1986-2005) allowed us to compare the Hg temporal trends reported by Bustnes et al. (2013) during the same period using the same population of tawny owl but a different matrix (i.e., feather).

During the exploration of the dataset, a sudden shift in Hg concentrations was observed between 2000 and 2005 (Annex 15). This seemed to be supported by a significant difference in Hg concentrations between the two shorter study periods as well as the year 2005 (along with 2014) presenting the most statistical pairwise differences in mean concentrations with the other studied years (Annex 11). Over the first period (1986-2005) a significant decrease in Hg concentrations in tawny owl eggs was observed (Figure 8) and temperature and ∂^{13}C were found to be the best predictors. In sharp contrast, no statistical trend in Hg concentrations was found for the second period (2006-2019; Figure 9), although temperature and ∂^{13}C were also identified to be the best predictors. Over the entire period (1986-2019), a decreasing trend in Hg concentrations was observed with temperature and ∂^{13}C being consistently the main predictors of Hg concentrations (Figure 7; Table 4).

4.1 Background studies

Mercury, as a non-essential toxic metal, is considered as a metal of concern due to its adverse biological effects (Walker et al. 2012). However, few studies focused on terrestrial raptors in sub-Arctic climate (Bustnes et al. 2013; Sun et al. 2019). As previously mentioned, many studies focused on the impact of mercury (i.e., toxic effects on ecosystems and wildlife, and human health, e.g., Wolfe et al. 1998; Tan et al. 2009) but also on the temporal (Braune et al. 2001; Harmens et al. 2008) and spatial (Braune et al. 2002, Schoch et al. 2020) variations in concentrations. However, these studies have predominately been focusing on mammals (Rigét et al. 2007; Dietz et al. 2011), fish (Rasmussen et al. 2007; Grieb et al. 2019), and seabirds (Braune et al. 2001, 2002) and on the Arctic (Braune et al. 2001, 2002). Moreover, studies on the mercury temporal trends over a long period of time are scarce and are mainly focusing on atmospheric mercury (Berg et al. 2008; Custódio et al. 2022;) or seabirds (Braune 2006; Helgason et al. 2008; Weseloh et al. 2011; Tartu et al. 2022).

Previous studies (Bustnes et al. 2007, 2011, 2013, 2015; Ahrens et al. 2011) have studied the same tawny owl population without consistently using the same matrix (i.e., Bustnes et al. 2013 used feathers). The temporal trends of POPs were investigated between 1986 and 2004 (Bustnes et al. 2007), and between 1986 and 2009 (Bustnes et al. 2011). In 2013, Bustnes et al. investigated the temporal trends of thirty-nine essential and non-essential elements (including Hg) between 1986 and 2005. Among the thirty-nine elements investigated, a decrease in concentrations were found for eleven metals, though not for Hg. However, this investigation using feathers did not incorporate the potential influence of dietary ecological parameters (stable isotopes) nor climate variables. Per- and polyfluoroalkyl substances (PFAS) concentrations were investigated in 1986-2009 by Bustnes et al. (2015). Among these studies, only two investigated the influence of climatic variables and dietary ecological parameters (Bustnes et al. 2011 and Bustnes et al. 2015). Bustnes et al. (2011) found both positive and negative associations between the different POPs investigated and the climate variables. Bustnes et al. (2015) also found similar results however, there was a complex interaction with temperature and feeding conditions. Temporal trends of polyfluoroalkyl compounds (PFCs) were investigated between 1986 and 2009 by Ahrens et al. (2011) using tawny owl eggs.

Despite using the same tawny owl population, discrepancies between the previous studies and the present study can be explained by several factors. In Bustnes et al. (2011, 2015), mean temperatures and mean max snow depths were calculated based on the data collected for the first trimester of a specific year (January$_{\text{Year}}$ to March$_{\text{Year}}$), period considered as the harsher part of winter. Conversely, in the current study, we decided to add December$_{\text{Year-1}}$ to calculate the mean temperature and the mean max snow depth for the entire winter (December$_{\text{Year-1}}$ to March$_{\text{Year}}$). This decision was made to be matching the winter NAOI which is calculated by doing the mean from December$_{\text{Year-1}}$ to March$_{\text{Year}}$. Moreover, the current study assessed for the first time Hg and stable isotopes in eggs of this population of tawny owls.

4.2 Eggs as a matrix to assess mercury temporal trends

As aforementioned, Hg concentrations were found to be higher between 1986-2005 than between 2006-2019. A slight decreasing and non-linear trend was observed for the Hg concentrations (Figure 5a) in the first period contrary to the second period when no significant trend was observed (Figure 5b). The non-linear trends found for the first period (1986-2005) in the present study are in contradiction with the results previously reported by Bustnes et al. (2013). Indeed, for the 1986-2005 period, Bustnes et al. (2013) observed no significant Hg trends using tawny owl feathers. Braune (2006) found no temporal variations in Hg concentrations in black-legged kittiwake (*Rissa tridactyla*) eggs between 1975 and 2003. On the contrary, Braune (2006) found that mercury concentrations in eggs of thick-billed murres (*Uria lomvia*) and northern fulmars (*Fulmarus glacialis*) increased over the same period. Helgason et al. (2008) investigated the temporal trends of POPs and Hg between 1983 and 2003 using eggs of herring gulls (*Larus argentatus*), black-legged kittiwakes, common guillemots (*Uria aalge*), and Atlantic puffins (*Fratercula arctica*) in Northern Norway, not observing any significant temporal trends. Our results for the second period are however in accordance with previous studies. Schoch et al. (2020) found no variations in Hg concentrations in adult common loon (*Gavia immer*) feathers and blood during the period 2010 to 2016. No significant trends were found in black-legged kittiwake eggs between 1993 and 2015 from Hudson Bay (Canada; Morris et al. 2022). When accounting for the entire period studied in the current study where we found an overall linear decrease in Hg concentrations, the decrease in Hg concentrations have also been observed by previous studies using different species and matrices. Weseloh et al. (2011) found a decrease in Hg concentrations in herring gull eggs over the 1974-2009 period in the Great Lakes region, and the decreases are thought to have been induced by the diet. A similar decrease in Hg concentrations has been reported using the Norwegian population of white-tailed eagle (*Haliaeetus albicilla*) feathers between 1958 and 2015 (Sun et al. 2019). A similar decrease has been observed in herring gull eggs over the period 1980 to 2012 (Hebert and Popp 2018). Braune et al. (2016) found, after adjusting Hg concentrations with the dietary ecology, a slight decrease in Hg concentrations in eggs of thick-billed murres, northern fulmars, black guillemots (*Cepphus grylle*), and black-legged kittiwakes between 1993 and 2013. Conversely, Tartu et al. (2022) found an increase in mercury concentrations in Arctic black-legged kittiwake blood since 2013 in connection with a diet shift and shrinking sea-ice extent. No trends were found in Hg concentrations over more than three decades in herring gull eggs from a sub-Arctic Canadian Lake after adjusting with diet (Herbert et al. 2021).

When accounting for Hg concentrations only, the temporal trends found in the present study and the temporal trends found by previous studies varied depending on the matrix and species used. Agusa et al. (2005) stated that maternal transfer of Hg to the eggs is substantially low and can also depend on the studied species. Additionally, Ackerman et al. (2020) stated that the transfer of Hg from the mother to the egg differs between taxa and with the maternal exposure to Hg. Moreover, the laying sequence was shown to influence Hg concentrations in Quail (*Coturnix coturnix*) eggs (Lewis & Furness 1993). Hg concentrations in the later produced eggs derived from the Hg stored in the maternal body, in comparison with the first produced eggs which derived totally from the diet (Lewis & Furness 1993).

The total emissions of Hg (i.e., from natural and anthropogenic sources) decreased between 1990 and 2010, especially across Europe (Ilyin et al. 2004; Zhang et al. 2016). The decrease in Hg emissions was reflected in the concentrations of Hg present in the air which decreased from 1991 to 2005 (Berg et al. 2008). However, the total gaseous mercury (TGM) known as atmospheric Hg showed no trends in the period 1995 to 2002 (Wängberg et al. 2007). This can be explained by the hemispherical background concentrations which are transported through atmospheric current over long distances, and by natural emission sources and re-emissions of Hg (Ilyin et al. 2004; Wängberg et al. 2007). A small decline was observed between 2010 and 2015 in TGM in Western Europe (Streets et al. 2019) and a decrease in gaseous elemental mercury (GEM; the main component of TGM) was observed in Andøya (Northern Norway) from 2010 to 2020 (Custódio et al. 2022). A significant decrease in wet deposition of Hg has also been observed between 1995 and 2002 because of the mitigation measures implemented in Europe (Wängberg et al. 2007). However, the decrease in wet deposition and atmospheric mercury is in contrast with the Hg concentrations found in mosses between 1995 and 2000 across Europe (Harmens et al. 2008) which are used to measure the deposition (i.e., dry, and wet deposition) of Hg (Harmens et al. 2010).

4.3 Mercury toxicity

The Hg toxicity threshold in bird eggs was defined by Fuchsman et al. (2017). The toxicity threshold ranges from 0.6 to 2.7 µg g^{-1} (*ww*). In the present study, none of the maximum nor mean values of Hg concentrations (*ww*; Annex 3) were above the aforementioned toxicity threshold lower value for the whole period (1986-2019). Moreover, Ackermann et al. (2016b) and Dietz et al. (2021) defined the risk categories for Hg exposure (in µg.g^{-1} *ww*) and none of the maximum values nor mean values of Hg concentrations (*ww*) were above the low risk level. We can thus assume that Hg concentrations in adult females were also below the toxicity threshold. Indeed, Tartu et al. (2013) and Goutte et al. (2015) found that Hg concentrations in black-legged kittiwake blood prior the breeding season affected the breeding success. However, if the pre-breeding Hg concentrations acted as a cofactor dictating the breeding success, the collected eggs for the current study might not represent the entire population of tawny owl. Indeed, the total Hg concentrations (*ww*) might exceed the toxicity threshold in individuals that did not breed. Moreover, egg Hg concentrations are, as in blood, primarily under the MeHg form (Evers et al. 2005; Ackerman et al. 2013) but inorganic Hg can be found in other tissues (e.g., liver). Therefore, the eggs alone might not be a sufficient matrix to assess the toxicity in the entire population of tawny owls.

4.4 Influence of predictors variables

The model selection procedure, performed to assess which explanatory variables (i.e., temperature, max snow depth (precipitations), NAOI, $\partial^{13}C$, and $\partial^{15}N$) may have had an impact on the Hg temporal trend, suggested temperature and $\partial^{13}C$ as best predictors to explain the observed temporal Hg variability. In fact, the same model, composing Year + Temperature + $\partial^{13}C$, seems to act as the most parsimonious model. As aforementioned, a decrease in Hg concentrations influenced by temperature and $\partial^{13}C$ was observed after plotting the partial residuals from the most parsimonious model for the first period (1986-2005; Figure 8). No significant trend was observed for the second period (2006-2019; Figure 9) despite the influence of temperature and $\partial^{13}C$. Over the entire period (1986-2019; Figure 7), temperature and $\partial^{13}C$ were found to be the main factors responsible for the decrease in Hg concentrations. The best model found for the entire period showed that the interaction between temperature and the feeding habitat explained less compared to the association between the temperature and feeding habitat found in the most parsimonious model.

The analysis of stable isotopes has proven to be a useful tool to investigate Hg contamination (Fry 2006). In the present study, we found that ∂^{13}C decreased since 1995 until approximately 2011 (Figure 6d) and was positively correlated with the Hg concentrations in the eggs, making ∂^{13}C a suitable predictor of the Hg concentrations. Braune et al. (2002) found spatial variations in Hg concentrations in several sites across the Canadian Arctic using eggs of glaucous gulls, black-legged kittiwakes, thick-billed murres, and black guillemots. These spatial variations can be imputed to atmospheric depositions which varied depending on the sampling location. Therefore, when analyzing ∂^{13}C, we must be careful and account for the variations in Hg depositions which can, even on a local scale, influence Hg concentrations. Sunde et al. (2001) found an average increase of 54% of the tawny owl's home range during winter when compared to summer. Adult tawny owls might have fed at a different location after 1995. Moreover, Hallinger & Cristol (2011) found significant differences in Hg concentrations in relation to the feeding habitat in tree swallows (*Tachycineta bicolor*). Espín et al. (2014) found that the role of diet was less significant than the local contamination of the environment using Hg concentrations in blood of eagle owls (*Bubo bubo*). The change in feeding location might be in correlation with the tawny owl's preferred prey abundance. Indeed, ∂^{15}N decreased between 1986 and 2005. When the abundance of the preferred prey is low, tawny owls are known to switch prey (Petty 1999). However, no correlation was found between Hg concentrations and ∂^{15}N. Therefore, even if a change in trophic level occurred in the studied period, it did not seem to be a valuable predictor of temporal Hg variability.

As previously described, a positive NAOI can lead to warmer conditions in northern Europe and an increased number of storm events and precipitations. Between 1986 and 2019, the mean NAOI was systematically positive and increased since 2006 after a slight decrease from 1989 (Figure 6c). Moreover, we found that the concentrations in Hg were negatively correlated with the winter air temperatures. Indeed, warmer years have been shown to negatively impact the abundance of field voles (Selås et al. 2019) leading to a switch in tawny owl's prey. Accordingly, Selås et al. (2019) found that snow depth seems to be less important in field vole population dynamic than air temperature. Therefore, temperature likely influences prey dynamics and dietary ecology of tawny owls more than Hg concentrations directly. Conversely, as the NAOI decreased between 1986 and 2005, the temperatures were lower and led to more favorable conditions for the tawny owl's preferred prey. This could explain why we found a decrease in ∂^{15}N during the same period. As the NAOI increased after 2005, the temperatures got warmer (Wanner et al. 2001). As a result, we suspect that the abundance of field voles decreased causing a shift in prey that might have led to the increase in ∂^{15}N observed between 2005 and 2019 (Figure 6e). A negative NAOI led to dry and cold winters.

Snowfalls are effective scavengers of atmospheric Hg (Lalonde et al. 2002). NAOI was, however, not correlated with the max snow depth in the current study for the entire period. This lack of correlation is in contradiction with the fact that a positive NAOI suggests an increase in the number of storm events and precipitations. As previously mentioned, a decrease in Hg wet deposition has been observed between 1995 and 2002 in Europe (Wängberg et al. 2007). Additionally, a rapid decrease in Hg concentrations in fresh snow occurs within 24 hours due to reduction and re-emission (Lalonde et al. 2002). However, we found that max snow depth had very low to no impact on the variation of the Hg concentrations over the entire study period. The low impact of precipitations was also found in a previous study (Hallinger & Cristol 2011). The decrease in Hg wet depositions and the quick reduction and re-emission of Hg after snowfall can explain why max snow depth had a very low or no impact on egg Hg concentrations. Furthermore, no correlation was found between HgDw and max snow depth.

4.5 Limitations and highlights of the study

As the atmospheric Hg and the wet deposition decreased, and the quick re-emission of freshly deposited Hg through snowfall episodes to the atmosphere, a decrease should have subsequently occurred in the adult tawny owl. However, MeHg is the main form of Hg in eggs and therefore, does not represent the total Hg concentration in the adult. In addition, depending on the laying sequence of the eggs, Hg in eggs does not have the same origin and depending on the number of eggs per clutch, the Hg concentrations might be diluted. Moreover, since females reduce their Hg burden by excreting MeHg through the eggs, eggs show lower Hg concentrations than adult females (Lewis & Furness 1993). Collecting one egg per clutch can hinder the interpretability of Hg concentrations as intra-clutch variations in egg Hg concentrations might arise (Ackerman et al. 2016a). Therefore, using only the eggs to investigate Hg temporal trends might not be enough to characterize the temporal trends of Hg.

However, using tawny owl eggs present an advantage as the clutches present generally two to three eggs. Hg concentrations might therefore not vary much between laid eggs and are more susceptible to represent the recent Hg uptake from the adult female. Despite the limitations related to using eggs, eggs remain a matrix which is easily sampled, with an easily reproducible sampling pattern that does not cause distress to the individual unlike other matrices (e.g., blood).

The current study emphasized the importance of climate variables and feeding habitat. Indeed, winter air temperature and $\partial^{13}C$ were found to be the predictors that explained best our temporal trends. Additionally, having data for each year of the study period helped us to highlight sudden shifts in Hg concentrations which might not have been spotted if sampling had been done with a greater time lag (e.g., every fifth year).

Therefore, further studies should investigate different matrices in association with eggs to better assess Hg temporal trends. Mallory & Braune (2018) showed that, although eggs reflect a recent local contamination of Hg, liver tissue might bring deeper information on long-term exposure. Moreover, the use of chick feathers from birds of prey were found to be more reliable to assess local environmental pollution (Lodenius & Solonen 2013).

5 Conclusion

The present study showed a significant decrease in Hg concentrations of -2.40% over the last three decades. Moreover, we reported a sudden shift in concentration between 2000 and 2005 with 2005 having a significantly lower Hg concentration than the previous years. Over the period 1986-2019, none of the maximum nor mean values for Hg concentrations were above the toxicity threshold, therefore, no risk for tawny owl's health was observed.

Among the selected candidate models, air temperature and $\partial^{13}C$ were found to be the best predictors explaining the temporal changes in Hg concentrations in tawny owl eggs. Conversely, max snow depth, NAOI and $\partial^{15}N$ were found to have a very low to no influence on the Hg concentrations in eggs. Nevertheless, the most parsimonious model explained at best 35.50% of the observed variability, implying that other processes must be at work. Additionally, despite the limitations pertaining to using eggs as a matrix to assess Hg concentrations, the use of eggs was shown to be suitable to investigate the temporal trends of Hg over a long period of time.

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6 Annexes

Annex 1: Complete data used for GAM modelling. ID: Identification number; Ring: Ring number; Journalnr.: journal entry number; T: Temperature (°C); MS: Max Snow depth (cm); NAOI: North Atlantic Oscillation Index; HgDw: Dry Weight Mercury concentration (µg.g^{-1}); HgWw: Wet Weight Mercury concentration (µg.g^{-1}); C: Carbon; N: Nitrogen; C:N: ratio Carbon:Nitrogen; d13C: stable carbon isotope value (∂^{13}C); d15N: stable nitrogen isotope value (∂^{15}N). Temperature; Max Snow depth and North Atlantic Oscillation Index values are based on the mean of the winter values (December-March).

Location	ID	Ring	Year	Journalnr.	T	MS	NAOI	HgDw	HgWw	C	N	C:N	d13C	d15N
Trondheim	150	335116	1986	386	-3.45	105.1	0.6	0.18	0.02	51.10	7.41	6.89	-27.94	7.55
Trondheim	148	N/A	1986	384	-3.45	105.1	0.6	0.09	0.02	51.07	6.16	8.30	-27.88	8.99
Trondheim	72	321813	1987	305	-4.025	71.6	-0.6	0.11	0.02	46.66	8.61	5.42	-27.34	9.76
Trondheim	152	332649	1987	388	-4.025	71.6	-0.6	0.12	0.03	44.30	9.92	4.46	-26.03	8.14
Trondheim	151	336284	1987	387	-4.025	71.6	-0.6	0.31	0.09	40.99	5.52	7.43	-25.89	8.57
Trondheim	104	339569	1987	338	-4.025	71.6	-0.6	0.20	0.05	53.85	5.51	9.78	-28.88	8.14
Trondheim	102	N/A	1987	336	-4.025	71.6	-0.6	0.19	0.04	49.60	7.06	7.03	-26.79	8.32
Trondheim	97	332691	1989	331	2.625	78.5	2.325	0.04	0.01	49.53	7.35	6.74	-28.57	8.34
Trondheim	95	332699	1989	329	2.625	78.5	2.325	0.03	0.01	53.35	8.42	6.33	-28.07	7.26
Trondheim	121	335117	1989	355	2.625	78.5	2.325	0.02	0.00	33.32	8.25	4.04	-27.66	10.69
Trondheim	133	335118	1989	367	2.625	78.5	2.325	0.03	0.01	31.67	7.73	4.10	-26.63	7.46
Trondheim	117	332679	1990	351	1.65	58.7	1.275	0.17	0.03	44.40	8.67	5.12	-27.41	9.49
Trondheim	67	332646	1991	300	0.5	28.1	0.55	0.07	0.02	60.74	5.29	11.49	-29.31	10.82
Trondheim	69	335160	1991	302	0.5	28.1	0.55	0.21	0.06	50.04	7.57	6.61	-28.10	8.96
Trondheim	107	335170	1991	341	0.5	28.1	0.55	0.11	0.02	45.56	9.08	5.02	-26.62	7.18
Trondheim	50	335171	1991	283	0.5	28.1	0.55	0.11	0.02	54.02	7.72	6.99	-28.12	5.62
Trondheim	41	335172	1991	274	0.5	28.1	0.55	0.08	0.02	52.54	8.79	5.98	-27.88	7.93
Trondheim	73	335175	1991	306	0.5	28.1	0.55	0.20	0.04	48.45	7.52	6.44	-27.51	5.44
Trondheim	46	335185	1991	279	0.5	28.1	0.55	0.15	0.03	52.65	8.68	6.07	-28.39	5.80
Trondheim	87	336371	1991	321	0.5	28.1	0.55	0.24	0.05	47.17	9.17	5.14	-26.91	6.85
Trondheim	83	345976	1991	317	0.5	28.1	0.55	0.07	0.02	50.44	8.41	6.00	-27.18	8.65
Trondheim	124	345982	1991	358	0.5	28.1	0.55	0.09	0.02	41.88	8.47	4.94	-27.54	5.42
Trondheim	123	N/A	1991	357	0.5	28.1	0.55	0.20	0.04	56.22	5.30	10.60	-29.34	29.92
Trondheim	75	332679	1992	308	1.925	52.9	0.8	0.06	0.02	48.74	7.61	6.41	-28.09	8.37
Trondheim	52	332691	1992	285	1.925	52.9	0.8	0.08	0.02	53.49	10.37	5.16	-26.75	5.82
Trondheim	98	335159	1992	332	1.925	52.9	0.8	0.16	0.03	40.95	8.57	4.78	-27.34	5.55
Trondheim	77	336322	1992	311	1.925	52.9	0.8	0.05	0.01	57.14	8.03	7.12	-28.04	6.97
Trondheim	74	336339	1992	307	1.925	52.9	0.8	0.09	0.02	47.91	8.99	5.33	-27.10	5.79
Trondheim	129	339572	1992	363	1.925	52.9	0.8	0.02	0.00	54.75	6.99	7.83	-29.64	7.26
Trondheim	56	OB04501	1992	289	1.925	52.9	0.8	0.12	0.03	52.74	7.51	7.02	-27.92	4.62
Trondheim	115	OB04564	1992	349	1.925	52.9	0.8	0.12	0.03	50.03	7.66	6.54	-28.14	8.71
Trondheim	78	OB04576	1992	312	1.925	52.9	0.8	0.06	0.01	55.61	8.31	6.69	-28.59	6.81
Trondheim	118	OB04629	1992	352	1.925	52.9	0.8	0.13	0.03	9.47	1.24	7.66	-28.05	9.83
Trondheim	81	335159	1993	315	1.775	65.0	1.2	0.08	0.02	51.34	7.26	7.08	-27.17	7.21
Trondheim	8	335163	1993	240	1.775	65.0	1.2	0.08	0.02	49.93	8.99	5.55	-27.45	8.83
Trondheim	90	335178	1993	324	1.775	65.0	1.2	0.15	0.03	39.55	9.92	3.99	-26.02	8.58
Trondheim	29	336257	1993	261	1.775	65.0	1.2	0.24	0.04	53.61	9.03	5.94	-26.02	7.41
Trondheim	70	336305	1993	303	1.775	65.0	1.2	0.09	0.02	52.30	6.05	8.64	-28.33	6.54
Trondheim	99	OB04628	1993	333	1.775	65.0	1.2	0.21	0.04	47.04	9.07	5.19	-26.06	8.53
Trondheim	130	OB04629	1993	364	1.775	65.0	1.2	0.14	0.03	N/A	N/A	N/A	N/A	N/A
Trondheim	55	OB04686	1993	288	1.775	65.0	1.2	0.13	0.02	52.37	7.15	7.33	-27.27	9.78
Trondheim	93	OB04692	1993	327	1.775	65.0	1.2	0.08	0.02	46.50	10.00	4.65	-25.11	4.71
Trondheim	144	N/A	1993	380	1.775	65.0	1.2	0.03	0.01	N/A	N/A	N/A	N/A	N/A
Trondheim	30	335158	1994	262	-2.95	69.1	2.15	0.21	0.04	53.50	8.14	6.57	-27.51	9.20
Trondheim	58	336312	1994	291	-2.95	69.1	2.15	0.18	0.04	50.25	9.90	5.08	-27.35	7.32
Trondheim	49	336322	1994	282	-2.95	69.1	2.15	0.12	0.03	49.57	8.07	6.14	-28.17	9.33

Trondheim	44	OB04739	1994	277	-2.95	69.1	2.15	0.07	0.01	49.25	7.97	6.18	-27.78	10.73
Trondheim	128	OB04740	1994	362	-2.95	69.1	2.15	0.10	0.02	52.78	7.15	7.38	-28.40	9.58
Trondheim	106	OB04741	1994	340	-2.95	69.1	2.15	0.14	0.03	51.72	7.67	6.74	-27.15	6.24
Trondheim	110	OB04742	1994	344	-2.95	69.1	2.15	0.06	0.01	50.13	7.24	6.92	-28.60	7.85
Trondheim	138	OB04743	1994	374	-2.95	69.1	2.15	0.49	0.10	N/A	N/A	N/A	N/A	N/A
Trondheim	135	OB04745	1994	370	-2.95	69.1	2.15	0.36	0.06	49.02	5.18	9.47	-28.71	8.37
Trondheim	79	OB04748	1994	313	-2.95	69.1	2.15	0.14	0.03	53.89	6.22	8.67	-29.38	7.42
Trondheim	86	332679	1995	320	0.975	77.8	1.775	0.11	0.03	43.00	8.67	4.96	-25.93	6.15
Trondheim	114	339571	1995	348	0.975	77.8	1.775	0.04	0.01	55.16	8.78	6.28	-28.12	7.46
Trondheim	109	OB04677	1995	343	0.975	77.8	1.775	0.11	0.02	54.18	7.95	6.81	-27.25	7.52
Trondheim	35	OB04750	1995	268	0.975	77.8	1.775	0.11	0.02	50.40	10.64	4.74	-26.40	6.29
Trondheim	21	OB04772	1995	253	0.975	77.8	1.775	0.12	0.02	31.40	8.99	3.49	-27.05	7.49
Trondheim	112		1995	346	0.975	77.8	1.775	0.05	0.01	50.64	8.18	6.19	-28.40	8.10
Trondheim	57	335171	1996	290	-2.3	71.3	-1.825	0.09	0.02	51.37	6.94	7.40	-28.16	7.58
Trondheim	94	335178	1996	328	-2.3	71.3	-1.825	0.17	0.04	46.86	9.40	4.98	-25.77	7.81
Trondheim	68	339568	1996	301	-2.3	71.3	-1.825	0.12	0.02	49.86	8.08	6.17	-27.98	8.70
Trondheim	96		1996	330	-2.3	71.3	-1.825	0.12	0.03	50.22	8.80	5.71	-27.99	6.49
Trondheim	82	335158	1997	316	-0.35	68.9	-0.275	0.12	0.02	48.48	8.75	5.54	-27.42	7.60
Trondheim	84	335160	1997	318	-0.35	68.9	-0.275	0.07	0.02	48.42	7.62	6.36	-28.04	7.06
Trondheim	134	339568	1997	368	-0.35	68.9	-0.275	0.16	0.02	45.07	9.23	4.88	-26.51	8.02
Trondheim	16	OB04629	1997	248	-0.35	68.9	-0.275	0.15	0.04	52.03	11.18	4.65	-26.35	8.36
Trondheim	45	OB04671	1997	278	-0.35	68.9	-0.275	0.14	0.03	51.48	7.80	6.60	-27.56	5.54
Trondheim	32	OB04782	1997	264	-0.35	68.9	-0.275	0.11	0.02	51.68	9.30	5.56	-28.03	7.74
Trondheim	103	OB04793	1997	337	-0.35	68.9	-0.275	0.21	0.05	50.67	6.99	7.25	-28.63	6.19
Trondheim	63	336312	1998	296	0.15	54.8	0	0.09	0.02	51.21	8.15	6.28	-28.02	5.94
Trondheim	39	345976	1998	272	0.15	54.8	0	0.10	0.02	51.17	9.27	5.52	-25.80	4.20
Trondheim	100	OB04819	1998	334	0.15	54.8	0	0.09	0.02	50.26	8.01	6.27	-27.00	3.86
Trondheim	40	N/A	1998	273	0.15	54.8	0	0.24	0.06	48.61	8.41	5.78	-28.03	8.17
Trondheim	54	N/A	1998	287	0.15	54.8	0	0.19	0.04	52.57	8.81	5.97	-26.81	5.21
Trondheim	65	N/A	1998	298	0.15	54.8	0	0.12	0.03	50.31	8.97	5.61	-27.42	8.42
Trondheim	108	N/A	1998	342	0.15	54.8	0	0.08	0.01	23.57	3.67	6.42	-27.27	5.49
Trondheim	13	338322	1999	245	-0.55	48.3	1.325	0.13	0.02	52.46	7.95	6.60	-27.62	6.60
Trondheim	134	361912	1999	369	-0.55	48.3	1.325	0.12	0.03	50.71	5.48	9.26	-28.31	4.82
Trondheim	122	361913	1999	356	-0.55	48.3	1.325	0.25	0.05	56.50	6.94	8.14	-29.38	7.77
Trondheim	125	OB04694	1999	359	-0.55	48.3	1.325	0.05	0.01	51.20	7.42	6.90	-28.07	7.22
Trondheim	76	OB04892	1999	310	-0.55	48.3	1.325	0.12	0.02	48.13	9.24	5.21	-27.33	8.23
Trondheim	14	N/A	1999	246	-0.55	48.3	1.325	0.21	0.04	52.69	9.61	5.48	-26.09	6.75
Trondheim	28	N/A	1999	260	-0.55	48.3	1.325	0.14	0.03	54.67	11.37	4.81	-26.40	6.12
Trondheim	31	N/A	1999	263	-0.55	48.3	1.325	0.10	0.02	44.70	10.64	4.20	-26.06	5.22
Trondheim	62	320717	2000	295	0.125	93.4	1.325	0.09	0.01	51.23	7.99	6.41	-29.06	8.39
Trondheim	60	335162	2000	293	0.125	93.4	1.325	0.17	0.04	52.93	8.81	6.01	-101.66	7.58
Trondheim	10	339570	2000	242	0.125	93.4	1.325	0.29	0.06	54.99	8.29	6.64	-26.99	9.98
Trondheim	61	395506	2000	294	0.125	93.4	1.325	0.16	0.03	48.15	6.79	7.09	-29.16	7.56
Trondheim	127	395510	2000	361	0.125	93.4	1.325	0.06	0.01	52.72	7.73	6.82	-29.09	7.42
Trondheim	11	OB04758	2000	243	0.125	93.4	1.325	0.05	0.01	51.45	9.01	5.71	-28.30	7.59
Trondheim	59	OB04786	2000	292	0.125	93.4	1.325	0.07	0.01	52.64	8.39	6.27	-27.91	8.53
Trondheim	33	OB04992	2000	266	0.125	93.4	1.325	0.19	0.04	49.81	9.87	5.05	-27.45	7.59
Trondheim	101	N/A	2000	335	0.125	93.4	1.325	0.08	0.02	51.56	8.75	5.89	-27.33	10.02
Trondheim	132	N/A	2000	366	0.125	93.4	1.325	0.22	0.05	121.79	10.86	11.21	-30.00	9.01
Trondheim	12	N/A	2000	390	0.125	93.4	1.325	0.09	0.02	46.53	7.03	6.62	-27.37	8.50
Trondheim	7	334341	2001	389	-2.4	47.6	-1.075	0.06	0.01	N/A	N/A	N/A	N/A	N/A
Trondheim	1	395504	2001	233	-2.4	47.6	-1.075	0.15	0.03	54.64	8.96	6.10	-28.44	7.97
Trondheim	18	OB04779	2001	250	-2.4	47.6	-1.075	0.21	0.04	49.67	8.07	6.16	-27.63	5.95
Trondheim	27	OB04892	2001	259	-2.4	47.6	-1.075	0.08	0.02	63.64	10.29	6.19	-28.71	7.19
Trondheim	6	N/A	2001	238	-2.4	47.6	-1.075	0.06	0.01	52.89	9.45	5.60	-27.51	9.17
Trondheim	15	N/A	2001	247	-2.4	47.6	-1.075	0.05	0.01	52.83	9.74	5.42	-28.46	8.26
Trondheim	22	N/A	2001	254	-2.4	47.6	-1.075	0.06	0.01	27.63	7.90	3.49	-28.21	6.57
Trondheim	47	N/A	2001	280	-2.4	47.6	-1.075	0.05	0.01	49.42	10.27	4.81	-27.64	8.97
Trondheim	66	334345	2002	299	-0.625	77.4	-0.25	0.46	0.08	45.15	10.32	4.38	-25.87	6.51
Trondheim	26	395503	2002	258	-0.625	77.4	-0.25	0.25	0.03	62.80	13.15	4.78	-26.73	6.25
Trondheim	126	395622	2002	360	-0.625	77.4	-0.25	0.10	0.02	53.02	6.65	7.97	-26.04	10.51
Trondheim	88	395771	2002	322	-0.625	77.4	-0.25	0.13	0.03	47.68	6.54	7.29	-29.54	6.57

Trondheim	64	N/A	2002	297	-0.625	77.4	-0.25	0.08	0.02	49.61	8.20	6.05	-28.39	7.39
Trondheim	48	334329	2003	281	-1.15	42.7	-0.075	0.11	0.01	42.14	10.16	4.15	-25.35	7.66
Trondheim	80	383801	2003	314	-1.15	42.7	-0.075	0.19	0.04	50.54	7.72	6.54	-27.07	8.18
Trondheim	116	395507	2003	350	-1.15	42.7	-0.075	0.08	0.02	53.55	8.50	6.30	-27.06	7.48
Trondheim	111	395737	2003	345	-1.15	42.7	-0.075	0.15	0.03	53.18	8.39	6.34	-26.11	7.82
Trondheim	91	395757	2003	325	-1.15	42.7	-0.075	0.11	0.02	42.39	9.54	4.44	-25.75	9.98
Trondheim	19	395852	2003	251	-1.15	42.7	-0.075	0.13	0.03	35.18	10.07	3.49	-27.84	5.16
Trondheim	119	395874	2003	353	-1.15	42.7	-0.075	0.22	0.05	51.16	7.72	6.62	-26.99	7.63
Trondheim	51	395877	2003	284	-1.15	42.7	-0.075	0.18	0.03	54.65	7.96	6.87	-27.30	6.02
Trondheim	131	396000	2003	365	-1.15	42.7	-0.075	0.18	0.02	48.76	6.99	6.98	-27.12	7.42
Trondheim	85	N/A	2003	319	-1.15	42.7	-0.075	0.17	0.04	48.12	8.83	5.45	-26.79	8.03
Trondheim	143	N/A	2003	379	-1.15	42.7	-0.075	0.08	0.02	N/A	N/A	N/A	N/A	N/A
Trondheim	204	332679	2004	660	-0.1	60.6	-0.2	0.07	0.02	45.82	5.35	8.56	-29.31	7.73
Trondheim	207	361919	2004	663	-0.1	60.6	-0.2	0.12	0.03	56.01	6.08	9.22	-29.45	6.35
Trondheim	209	376977	2004	665	-0.1	60.6	-0.2	0.09	0.02	57.05	4.38	13.02	-27.82	4.02
Trondheim	203	395507	2004	659	-0.1	60.6	-0.2	0.03	0.01	51.05	8.36	6.10	-28.55	7.42
Trondheim	211	395707	2004	667	-0.1	60.6	-0.2	0.08	0.02	51.77	8.12	6.38	-29.07	6.34
Trondheim	213	395776	2004	669	-0.1	60.6	-0.2	0.11	0.01	42.04	9.23	4.55	-26.91	5.42
Trondheim	210	395851	2004	666	-0.1	60.6	-0.2	0.09	0.02	57.06	7.81	7.31	-28.55	6.33
Trondheim	212	395860	2004	668	-0.1	60.6	-0.2	0.03	0.01	48.04	7.95	6.04	-28.71	9.10
Trondheim	217	395861	2004	673	-0.1	60.6	-0.2	0.02	0.00	57.24	6.74	8.49	-30.23	8.22
Trondheim	218	395866	2004	674	-0.1	60.6	-0.2	0.18	0.04	49.71	8.08	6.15	-28.12	5.28
Trondheim	201	395874	2004	657	-0.1	60.6	-0.2	0.15	0.03	53.90	5.49	9.81	-28.90	6.21
Trondheim	216	395974	2004	672	-0.1	60.6	-0.2	0.10	0.02	48.46	6.68	7.25	-29.14	7.66
Trondheim	205	3010519	2004	661	-0.1	60.6	-0.2	0.07	0.01	49.32	5.76	8.56	-28.68	6.36
Trondheim	202	N/A	2004	658	-0.1	60.6	-0.2	0.04	0.01	53.81	5.48	9.82	-30.11	7.35
Trondheim	206	N/A	2004	662	-0.1	60.6	-0.2	0.14	0.02	46.96	6.69	7.02	-28.80	6.16
Trondheim	208	N/A	2004	664	-0.1	60.6	-0.2	0.09	0.02	45.14	8.94	5.05	-28.22	6.27
Trondheim	214	N/A	2004	670	-0.1	60.6	-0.2	0.03	0.01	49.26	7.45	6.61	-29.49	7.45
Trondheim	215	N/A	2004	671	-0.1	60.6	-0.2	0.08	0.02	49.88	7.65	6.52	-28.51	7.20
Trondheim	N/A	N/A	2004	#25	-0.1	60.6	-0.2	0.06	0.01	49.94	10.08	4.95	-27.86	7.22
Trondheim	N/A	N/A	2004	#26	-0.1	60.6	-0.2	0.22	0.05	54.75	8.55	6.40	-27.76	5.83
Trondheim	N/A	N/A	2004	#27	-0.1	60.6	-0.2	0.10	0.02	50.87	7.98	6.37	-28.53	5.52
Trondheim	N/A	395851	2004	#28	-0.1	60.6	-0.2	0.06	0.01	51.67	6.92	7.47	-29.84	4.64
Trondheim	N/A	395707	2004	#29	-0.1	60.6	-0.2	0.06	0.01	50.60	6.89	7.35	-29.83	7.20
Trondheim	N/A	3010758	2005	#20	0.125	81.3	0	0.02	0.00	57.62	7.49	7.69	-30.36	5.98
Trondheim	N/A	N/A	2005	#21	0.125	81.3	0	0.02	0.00	67.68	6.87	9.85	-29.36	8.31
Trondheim	N/A	N/A	2005	#22	0.125	81.3	0	0.04	0.01	48.54	7.74	6.27	-28.93	5.53
Trondheim	N/A	395874	2005	#23	0.125	81.3	0	0.05	0.01	55.31	7.02	7.87	-30.18	6.78
Trondheim	N/A	334302	2005	#24	0.125	81.3	0	0.04	0.01	48.90	9.29	5.26	-28.59	6.31
Trondheim	N/A	395874	2006	#16	-1.825	60.4	-0.55	0.09	0.02	52.95	8.24	6.42	-27.59	6.15
Trondheim	N/A	N/A	2006	#17	-1.825	60.4	-0.55	0.08	0.02	71.93	9.87	7.29	-28.76	4.69
Trondheim	N/A	3010849	2006	#19	-1.825	60.4	-0.55	0.06	0.01	58.90	9.14	6.44	-28.00	4.95
Trondheim	N/A	N/A	2007	#11	0.675	68.3	1.525	0.07	0.01	51.11	9.43	5.42	-28.21	5.95
Trondheim	N/A	3010588	2007	#12	0.675	68.3	1.525	0.03	0.01	59.55	6.14	9.70	-29.70	8.26
Trondheim	N/A	395899	2007	#13	0.675	68.3	1.525	0.03	0.01	39.99	4.81	8.31	-29.45	6.42
Trondheim	N/A	395874	2007	#14	0.675	68.3	1.525	0.09	0.02	54.15	7.23	7.49	-28.15	5.52
Trondheim	N/A	N/A	2007	#15	0.675	68.3	1.525	0.06	0.01	59.73	7.57	7.89	-29.65	6.97
Trondheim	N/A	3011555	2008	#6	0.8	78.0	1.075	0.04	0.01	57.75	5.75	10.04	-29.37	6.29
Trondheim	N/A	N/A	2008	#7	0.8	78.0	1.075	0.05	0.01	50.29	7.02	7.16	-28.20	6.57
Trondheim	N/A	N/A	2008	#8	0.8	78.0	1.075	0.06	0.01	57.51	6.88	8.36	-27.90	1.39
Trondheim	N/A	3011504	2008	#9	0.8	78.0	1.075	0.06	0.01	53.64	7.31	7.34	-28.96	4.99
Trondheim	N/A	3010863	2008	#10	0.8	78.0	1.075	0.09	0.02	57.08	7.01	8.14	-29.83	4.81
Trondheim	N/A	N/A	2009	#1	-0.95	83.3	0.9	0.07	0.01	56.17	6.77	8.29	-28.73	7.39
Trondheim	N/A	3011507	2009	#2	-0.95	83.3	0.9	0.12	0.02	56.91	6.38	8.93	-28.06	5.96
Trondheim	N/A	N/A	2009	#3	-0.95	83.3	0.9	0.06	0.01	60.79	7.07	8.59	-29.23	7.39
Trondheim	N/A	3011974	2009	#4	-0.95	83.3	0.9	0.07	0.01	57.14	7.71	7.41	-27.78	7.80
Trondheim	N/A	3000542	2009	#5	-0.95	83.3	0.9	0.11	0.02	53.54	8.95	5.98	-27.30	7.88
Trondheim	N/A	N/A	2010	TO 2010-3	-4.125	60.4	-2.9	0.13	0.03	50.50	7.88	6.41	-29.59	8.51
Trondheim	N/A	N/A	2010	TO 2010-7	-4.125	60.4	-2.9	0.15	0.03	51.76	6.09	8.49	-29.10	5.13
Trondheim	N/A	N/A	2010	TO 2010-8	-4.125	60.4	-2.9	0.16	0.03	53.89	6.15	8.77	-28.65	8.43
Trondheim	N/A	N/A	2010	TO 2010-9	-4.125	60.4	-2.9	0.06	0.01	49.35	6.70	7.36	-29.22	7.57

Trondheim	N/A	N/A	2011	TO 2011-1	-2.575	81.7	-1.15	0.07	0.02	55.96	6.28	8.91	-29.19	8.45
Trondheim	N/A	N/A	2011	TO 2011-2	-2.575	81.7	-1.15	0.06	0.01	52.64	8.65	6.08	-28.34	4.07
Trondheim	N/A	N/A	2011	TO 2011-3	-2.575	81.7	-1.15	0.07	0.01	55.64	5.02	11.08	-30.59	7.16
Trondheim	N/A	N/A	2011	TO 2011-4	-2.575	81.7	-1.15	0.04	0.01	49.65	6.96	7.14	-29.51	7.47
Trondheim	N/A	N/A	2011	TO 2011-5	-2.575	81.7	-1.15	0.13	0.03	53.07	6.20	8.56	-29.74	5.50
Trondheim	N/A	N/A	2011	TO 2011-6	-2.575	81.7	-1.15	0.14	0.03	49.83	5.99	8.33	-29.37	5.61
Trondheim	N/A	N/A	2011	TO 2011-7	-2.575	81.7	-1.15	0.11	0.02	53.04	6.98	7.60	-29.60	5.74
Trondheim	N/A	N/A	2011	TO 2011-8	-2.575	81.7	-1.15	0.08	0.02	48.32	6.98	6.92	-28.46	8.77
Trondheim	N/A	N/A	2011	TO 2011-9	-2.575	81.7	-1.15	0.02	0.01	45.52	7.28	6.26	-28.98	7.23
Trondheim	N/A	N/A	2011	TO 2011-10	-2.575	81.7	-1.15	0.06	0.01	46.79	8.60	5.44	-28.27	7.75
Trondheim	N/A	N/A	2012	TO 2012-1	0.475	58.9	1.85	0.09	0.02	51.34	7.39	6.94	-28.87	7.79
Trondheim	N/A	N/A	2012	TO 2012-2	0.475	58.9	1.85	0.09	0.03	49.49	8.14	6.08	-27.38	5.51
Trondheim	N/A	N/A	2012	TO 2012-3	0.475	58.9	1.85	0.10	0.02	50.76	7.55	6.73	-28.13	7.32
Trondheim	N/A	N/A	2012	TO 2012-4	0.475	58.9	1.85	0.06	0.01	50.59	7.77	6.51	-27.79	4.95
Trondheim	N/A	N/A	2012	TO 2012-5	0.475	58.9	1.85	0.05	0.01	46.41	8.62	5.39	-28.22	7.70
Trondheim	N/A	N/A	2012	TO 2012-6	0.475	58.9	1.85	0.07	0.02	53.90	5.64	9.55	-29.85	8.31
Trondheim	N/A	N/A	2012	TO 2012-7	0.475	58.9	1.85	0.06	0.01	54.97	7.73	7.11	-29.16	8.02
Trondheim	N/A	N/A	2012	TO 2012-9	0.475	58.9	1.85	0.12	0.03	46.94	6.91	6.79	-28.10	7.95
Trondheim	N/A	N/A	2013	TO 2013-1	-3.7	47.1	-0.95	0.03	0.01	58.98	5.75	10.26	-30.95	7.79
Trondheim	N/A	N/A	2013	TO 2013-2	-3.7	47.1	-0.95	0.06	0.01	51.39	6.27	8.20	-30.55	7.79
Trondheim	N/A	N/A	2014	TO 2014-2	2.275	36.7	2.3	0.07	0.02	53.11	7.93	6.70	-29.01	6.77
Trondheim	N/A	N/A	2014	TO 2014-3	2.275	36.7	2.3	0.03	0.01	49.39	7.76	6.36	-28.97	8.56
Trondheim	N/A	N/A	2014	TO 2014-4	2.275	36.7	2.3	0.02	0.01	52.83	8.49	6.23	-28.78	7.56
Trondheim	N/A	N/A	2014	TO 2014-5	2.275	36.7	2.3	0.07	0.02	42.06	7.87	5.34	-28.66	6.89
Trondheim	N/A	N/A	2014	TO 2014-6	2.275	36.7	2.3	0.02	0.00	51.84	6.88	7.53	-29.86	9.29
Trondheim	N/A	N/A	2014	TO 2014-7	2.275	36.7	2.3	0.03	0.01	48.84	9.74	5.01	-28.38	9.32
Trondheim	N/A	N/A	2014	TO 2014-8	2.275	36.7	2.3	0.02	0.01	50.31	6.67	7.54	-31.07	7.85
Trondheim	N/A	N/A	2014	TO 2014-9	2.275	36.7	2.3	0.03	0.01	51.89	7.79	6.66	-28.86	7.14
Trondheim	N/A	N/A	2014	TO 2014-10	2.275	36.7	2.3	0.10	0.02	49.81	9.64	5.17	-27.64	4.21
Trondheim	N/A	N/A	2015	TO 2015-1	1.525	48.3	2.975	0.04	0.01	47.79	9.03	5.30	-28.60	6.05
Trondheim	N/A	N/A	2015	TO 2015-2	1.525	48.3	2.975	0.13	0.02	50.66	4.31	11.76	-29.73	7.33
Trondheim	N/A	N/A	2015	TO 2015-3	1.525	48.3	2.975	0.03	0.01	48.99	7.14	6.86	-29.22	6.20
Trondheim	N/A	N/A	2017	TO 2017-1	1	61.9	0.8	0.02	0.00	43.95	7.20	6.11	-28.56	7.28
Trondheim	N/A	N/A	2017	TO 2017-2	1	61.9	0.8	0.03	0.01	51.01	7.54	6.76	-28.66	8.02
Trondheim	N/A	N/A	2017	TO 2017-3	1	61.9	0.8	0.01	0.00	51.29	6.51	7.88	-29.49	8.21
Trondheim	N/A	N/A	2017	TO 2017-4	1	61.9	0.8	0.03	0.01	49.25	7.38	6.68	-28.79	7.71
Trondheim	N/A	N/A	2017	TO 2017-5	1	61.9	0.8	0.12	0.02	48.09	8.38	5.74	-28.10	8.52
Trondheim	N/A	N/A	2017	TO 2017-6	1	61.9	0.8	0.09	0.02	50.55	7.16	7.06	-28.38	8.35
Trondheim	N/A	N/A	2017	TO 2017-7	1	61.9	0.8	0.09	0.02	49.00	7.07	6.93	-27.22	10.07
Trondheim	N/A	N/A	2017	TO 2017-8	1	61.9	0.8	0.14	0.03	54.89	6.40	8.57	-29.79	7.70
Trondheim	N/A	N/A	2017	TO 2017-9	1	61.9	0.8	0.07	0.02	52.90	6.53	8.10	-29.34	7.73
Trondheim	N/A	N/A	2017	TO 2017-10	1	61.9	0.8	0.07	0.02	44.69	7.96	5.62	-27.14	6.67
Trondheim	N/A	N/A	2018	TO 2018-1	-2.25	82.7	0.775	0.10	0.02	54.59	7.40	7.38	-29.26	8.59
Trondheim	N/A	N/A	2018	TO 2018-2	-2.25	82.7	0.775	0.07	0.02	54.42	7.83	6.95	-29.33	7.16
Trondheim	N/A	N/A	2018	TO 2018-3	-2.25	82.7	0.775	0.08	0.02	54.13	7.96	6.80	-28.06	8.45
Trondheim	N/A	N/A	2018	TO 2018-4	-2.25	82.7	0.775	0.09	0.02	46.70	8.17	5.72	-28.89	8.54
Trondheim	N/A	N/A	2018	TO 2018-5	-2.25	82.7	0.775	0.05	0.01	48.61	9.03	5.39	-28.92	5.59
Trondheim	N/A	N/A	2018	TO 2018-6	-2.25	82.7	0.775	0.11	0.02	60.11	9.45	6.36	-28.27	7.42
Trondheim	N/A	N/A	2018	TO 2018-7	-2.25	82.7	0.775	0.20	0.05	52.43	9.20	5.70	-29.40	8.59
Trondheim	N/A	N/A	2018	TO 2018-8	-2.25	82.7	0.775	0.04	0.01	52.01	8.01	6.49	-29.49	8.26
Trondheim	N/A	N/A	2018	TO 2018-9	-2.25	82.7	0.775	0.19	0.04	50.62	8.41	6.02	-29.19	8.43
Trondheim	N/A	N/A	2018	TO 2018-10	-2.25	82.7	0.775	0.05	0.01	54.83	8.87	6.18	-28.22	7.46
Trondheim	N/A	N/A	2019	TO 19-02	-0.3	64.4	0.725	0.04	0.01	50.14	7.70	6.51	-28.63	7.24
Trondheim	N/A	N/A	2019	TO 19-03	-0.3	64.4	0.725	0.05	0.01	52.04	6.85	7.60	-29.16	6.01
Trondheim	N/A	N/A	2019	TO 19-04	-0.3	64.4	0.725	0.10	0.02	50.07	7.27	6.88	-28.16	8.37
Trondheim	N/A	N/A	2019	TO 19-05	-0.3	64.4	0.725	0.08	0.02	49.02	7.57	6.48	-28.16	7.83
Trondheim	N/A	N/A	2019	TO 19-06	-0.3	64.4	0.725	0.08	0.02	47.06	8.92	5.28	-27.50	8.48
Trondheim	N/A	N/A	2019	TO 19-07	-0.3	64.4	0.725	0.14	0.03	50.21	8.96	5.61	-27.78	8.88
Trondheim	N/A	N/A	2019	TO 19-08	-0.3	64.4	0.725	0.13	0.03	52.78	8.42	6.27	-26.73	7.92
Trondheim	N/A	N/A	2019	TO 19-09	-0.3	64.4	0.725	0.04	0.01	47.55	8.34	5.70	-27.94	7.98
Trondheim	N/A	N/A	2019	TO 19-10	-0.3	64.4	0.725	0.04	0.01	51.06	10.78	4.74	-27.02	8.70

Annex 2: Mercury concentration (dry weight) in µg.g^{-1}. Max: Maximum concentrations detected for a specific year; Min: Minimum concentration detected for a specific year; SD: Standard Deviation from the mean; N: Number of eggs sampled per year.

Year	Max	Min	Mean	SD	N
1986	0.177	0.089	0.133	0.062	2
1987	0.307	0.105	0.182	0.081	5
1988*	N/A	N/A	N/A	N/A	N/A
1989	0.040	0.024	0.032	0.006	4
1990**	0.171	0.171	0.171	N/A	1
1991	0.241	0.066	0.134	0.063	10
1992	0.159	0.020	0.090	0.042	10
1993	0.236	0.077	0.133	0.060	8
1994	0.355	0.059	0.153	0.089	9
1995	0.115	0.044	0.090	0.033	6
1996	0.165	0.086	0.122	0.032	4
1997	0.207	0.071	0.138	0.043	7
1998	0.244	0.076	0.130	0.062	7
1999	0.250	0.046	0.140	0.063	8
2000	0.285	0.047	0.128	0.079	10
2001	0.206	0.050	0.095	0.059	7
2002	0.464	0.084	0.206	0.158	5
2003	0.221	0.081	0.152	0.042	10
2004	0.216	0.021	0.088	0.048	23
2005	0.045	0.018	0.032	0.011	5
2006	0.087	0.057	0.074	0.015	3
2007	0.089	0.029	0.056	0.026	5
2008	0.089	0.043	0.060	0.017	5
2009	0.121	0.061	0.088	0.026	5
2010	0.159	0.064	0.124	0.042	4
2011	0.142	0.022	0.078	0.038	10
2012	0.119	0.045	0.078	0.026	8
2013	0.056	0.027	0.042	0.020	2
2014	0.102	0.019	0.044	0.029	9
2015	0.128	0.033	0.066	0.053	3
2016*	N/A	N/A	N/A	N/A	N/A
2017	0.136	0.015	0.065	0.042	10
2018	0.196	0.037	0.096	0.054	10
2019	0.141	0.035	0.077	0.039	9

*No sampled collected for the year.

**Not enough sample to calculate SD

Annex 3: Mercury concentration (wet weight) in µg.g^{-1}. Max: Maximum concentrations detected for a specific year; Min: Minimum concentration detected for a specific year; SD: Standard Deviation from the mean; N: Number of eggs sampled per year.

Year	Max	Min	Mean	SD	N
1986	0.024	0.020	0.022	0.003	2
1987	0.087	0.024	0.045	0.025	5
1988*	N/A	N/A	N/A	N/A	N/A
1989	0.008	0.002	0.006	0.003	4
1990**	0.025	0.025	0.025	N/A	1
1991	0.060	0.016	0.030	0.016	10
1992	0.030	0.004	0.019	0.008	10
1993	0.041	0.017	0.026	0.010	8
1994	0.064	0.012	0.031	0.016	9
1995	0.025	0.008	0.019	0.008	6
1996	0.044	0.019	0.028	0.011	4
1997	0.046	0.016	0.027	0.011	7
1998	0.056	0.015	0.028	0.014	7
1999	0.054	0.009	0.028	0.014	8
2000	0.059	0.010	0.026	0.018	10
2001	0.039	0.010	0.019	0.011	7
2002	0.080	0.017	0.036	0.025	5
2003	0.051	0.015	0.029	0.011	10
2004	0.052	0.005	0.018	0.012	23
2005	0.010	0.004	0.007	0.002	5
2006	0.019	0.009	0.015	0.006	3
2007	0.019	0.006	0.011	0.005	5
2008	0.019	0.008	0.013	0.004	5
2009	0.023	0.011	0.015	0.005	5
2010	0.034	0.015	0.028	0.009	4
2011	0.029	0.006	0.017	0.008	10
2012	0.031	0.010	0.018	0.007	8
2013	0.013	0.006	0.009	0.005	2
2014	0.021	0.005	0.010	0.006	9
2015	0.022	0.007	0.012	0.009	3
2016*	N/A	N/A	N/A	N/A	N/A
2017	0.029	0.003	0.015	0.009	10
2018	0.047	0.008	0.021	0.012	10
2019	0.030	0.008	0.017	0.008	9

*No sampled collected for the year.

**Not enough sample to calculate SD

Annex 4: Mean air temperature (°C) per month collected for the study period (1986-2019). The data were collected from the Værnes station (near Trondheim Airport (Trøndelag. Central Norway) as it covered the whole period. The winter temperature used for the data analyses correspond at the mean temperature from December$_{\text{Year–1}}$ to March$_{\text{Year}}$.

Station name	Station number	Time (Norwegian mean time)	Mean air temperature (month)
Værnes	SN69100	12.1985	-3.8
Værnes	SN69100	01.1986	-8.1
Værnes	SN69100	02.1986	-5.1
Værnes	SN69100	03.1986	3.2
Værnes	SN69100	12.1986	-3.1
Værnes	SN69100	01.1987	-9.1
Værnes	SN69100	02.1987	-2.1
Værnes	SN69100	03.1987	-1.8
Værnes	SN69100	12.1988	0.7
Værnes	SN69100	01.1989	3.2
Værnes	SN69100	02.1989	2.5
Værnes	SN69100	03.1989	4.1
Værnes	SN69100	12.1989	-1
Værnes	SN69100	01.1990	0.2
Værnes	SN69100	02.1990	4.6
Værnes	SN69100	03.1990	2.8
Værnes	SN69100	12.1990	1.6
Værnes	SN69100	01.1991	-0.4
Værnes	SN69100	02.1991	-2.6
Værnes	SN69100	03.1991	3.4
Værnes	SN69100	12.1991	1.5
Værnes	SN69100	01.1992	2
Værnes	SN69100	02.1992	1
Værnes	SN69100	03.1992	3.2
Værnes	SN69100	12.1992	1.3
Værnes	SN69100	01.1993	1.3
Værnes	SN69100	02.1993	0.4
Værnes	SN69100	03.1993	0.9
Værnes	SN69100	12.1993	-2.8
Værnes	SN69100	01.1994	-3.3
Værnes	SN69100	02.1994	-6.7
Værnes	SN69100	03.1994	1
Værnes	SN69100	12.1994	2.2
Værnes	SN69100	01.1995	-0.7
Værnes	SN69100	02.1995	0.7
Værnes	SN69100	03.1995	1.7
Værnes	SN69100	12.1995	-2.9
Værnes	SN69100	01.1996	-2.7
Værnes	SN69100	02.1996	-4.1
Værnes	SN69100	03.1996	0.5
Værnes	SN69100	12.1996	-3
Værnes	SN69100	01.1997	0.5
Værnes	SN69100	02.1997	0.1
Værnes	SN69100	03.1997	1
Værnes	SN69100	12.1997	-0.9
Værnes	SN69100	01.1998	-0.1
Værnes	SN69100	02.1998	1.2
Værnes	SN69100	03.1998	0.4

Værnes	SN69100	12.1998	-0.8
Værnes	SN69100	01.1999	-2.1
Værnes	SN69100	02.1999	-0.7
Værnes	SN69100	03.1999	1.4
Værnes	SN69100	12.1999	-3.9
Værnes	SN69100	01.2000	2
Værnes	SN69100	02.2000	1.4
Værnes	SN69100	03.2000	1
Værnes	SN69100	12.2000	-1.9
Værnes	SN69100	01.2001	-0.4
Værnes	SN69100	02.2001	-4.8
Værnes	SN69100	03.2001	-2.5
Værnes	SN69100	12.2001	-2.5
Værnes	SN69100	01.2002	-1.6
Værnes	SN69100	02.2002	1.1
Værnes	SN69100	03.2002	0.5
Værnes	SN69100	12.2002	-3.4
Værnes	SN69100	01.2003	-3.4
Værnes	SN69100	02.2003	-1.1
Værnes	SN69100	03.2003	3.3
Værnes	SN69100	12.2003	0.5
Værnes	SN69100	01.2004	-3.3
Værnes	SN69100	02.2004	-0.2
Værnes	SN69100	03.2004	2.6
Værnes	SN69100	12.2004	0.8
Værnes	SN69100	01.2005	1.9
Værnes	SN69100	02.2005	-1.5
Værnes	SN69100	03.2005	-0.7
Værnes	SN69100	12.2005	-1.3
Værnes	SN69100	01.2006	-0.3
Værnes	SN69100	02.2006	-1.1
Værnes	SN69100	03.2006	-4.6
Værnes	SN69100	12.2006	4.5
Værnes	SN69100	01.2007	-0.7
Værnes	SN69100	02.2007	-4.4
Værnes	SN69100	03.2007	3.3
Værnes	SN69100	12.2007	0
Værnes	SN69100	01.2008	1
Værnes	SN69100	02.2008	1.4
Værnes	SN69100	03.2008	0.8
Værnes	SN69100	12.2008	-1.2
Værnes	SN69100	01.2009	-0.9
Værnes	SN69100	02.2009	-3.6
Værnes	SN69100	03.2009	1.9
Værnes	SN69100	12.2009	-2.9
Værnes	SN69100	01.2010	-8.6
Værnes	SN69100	02.2010	-6.4
Værnes	SN69100	03.2010	-0.5
Værnes	SN69100	12.2010	-8.7
Værnes	SN69100	01.2011	-0.5
Værnes	SN69100	02.2011	-2.3
Værnes	SN69100	03.2011	1.2
Værnes	SN69100	12.2011	0.4
Værnes	SN69100	01.2012	-1.9

Værnes	SN69100	02.2012	-0.4
Værnes	SN69100	03.2012	3.8
Værnes	SN69100	12.2012	-5.1
Værnes	SN69100	01.2013	-3.9
Værnes	SN69100	02.2013	-2.9
Værnes	SN69100	03.2013	-2.9
Værnes	SN69100	12.2013	2.9
Værnes	SN69100	01.2014	-1.6
Værnes	SN69100	02.2014	4.2
Værnes	SN69100	03.2014	3.6
Værnes	SN69100	12.2014	-0.1
Værnes	SN69100	01.2015	0.4
Værnes	SN69100	02.2015	1.9
Værnes	SN69100	03.2015	3.9
Værnes	SN69100	12.2015	2.8
Værnes	SN69100	01.2016	-4
Værnes	SN69100	02.2016	-0.2
Værnes	SN69100	03.2016	2.6
Værnes	SN69100	12.2016	1.9
Værnes	SN69100	01.2017	1.1
Værnes	SN69100	02.2017	-0.5
Værnes	SN69100	03.2017	1.5
Værnes	SN69100	12.2017	-1.1
Værnes	SN69100	01.2018	-1.2
Værnes	SN69100	02.2018	-3.8
Værnes	SN69100	03.2018	-2.9
Værnes	SN69100	12.2018	-0.3
Værnes	SN69100	01.2019	-2.1
Værnes	SN69100	02.2019	0.8
Værnes	SN69100	03.2019	0.4

Annex 5: Max Snow depth (cm) per month collected for the study period (1986-2019). The data were collected from different stations (Trøndelag. Central Norway) for us to have enough data to cover the whole period (no stations were provided the data for the 33 years). The Max Snow depth used for the data analyses correspond at the mean Max Snow depth from December$_{\text{Year}-1}$ to March$_{\text{Year}}$.

Station name	Station number	Time (Norwegian mean time)	Max Snow depth (cm)
Berkåk - Lyngholt	SN66730	01.1986	100
Berkåk - Lyngholt	SN66730	01.1987	75
Berkåk - Lyngholt	SN66730	01.1989	125
Berkåk - Lyngholt	SN66730	01.1990	75
Berkåk - Lyngholt	SN66730	01.1991	15
Berkåk - Lyngholt	SN66730	01.1992	85
Berkåk - Lyngholt	SN66730	01.1993	63
Berkåk - Lyngholt	SN66730	01.1994	73
Berkåk - Lyngholt	SN66730	01.1995	80
Berkåk - Lyngholt	SN66730	01.1996	64
Berkåk - Lyngholt	SN66730	01.1997	80
Berkåk - Lyngholt	SN66730	01.1998	93
Berkåk - Lyngholt	SN66730	01.1999	34
Berkåk - Lyngholt	SN66730	01.2000	110
Berkåk - Lyngholt	SN66730	01.2001	68
Berkåk - Lyngholt	SN66730	01.2002	100
Berkåk - Lyngholt	SN66730	01.2003	75
Berkåk - Lyngholt	SN66730	01.2004	83
Berkåk - Lyngholt	SN66730	01.2005	147
Berkåk - Lyngholt	SN66730	01.2006	75
Berkåk - Lyngholt	SN66730	01.2008	110
Berkåk - Lyngholt	SN66730	02.1986	93
Berkåk - Lyngholt	SN66730	02.1987	120
Berkåk - Lyngholt	SN66730	02.1989	130
Berkåk - Lyngholt	SN66730	02.1990	60
Berkåk - Lyngholt	SN66730	02.1991	50
Berkåk - Lyngholt	SN66730	02.1992	85
Berkåk - Lyngholt	SN66730	02.1993	95
Berkåk - Lyngholt	SN66730	02.1994	50
Berkåk - Lyngholt	SN66730	02.1995	115
Berkåk - Lyngholt	SN66730	02.1996	70
Berkåk - Lyngholt	SN66730	02.1997	102
Berkåk - Lyngholt	SN66730	02.1998	86
Berkåk - Lyngholt	SN66730	02.1999	74
Berkåk - Lyngholt	SN66730	02.2000	135
Berkåk - Lyngholt	SN66730	02.2001	92
Berkåk - Lyngholt	SN66730	02.2002	125
Berkåk - Lyngholt	SN66730	02.2003	74
Berkåk - Lyngholt	SN66730	02.2004	125
Berkåk - Lyngholt	SN66730	02.2005	163
Berkåk - Lyngholt	SN66730	02.2006	112
Berkåk - Lyngholt	SN66730	02.2008	105
Berkåk - Lyngholt	SN66730	03.1986	100
Berkåk - Lyngholt	SN66730	03.1987	114
Berkåk - Lyngholt	SN66730	03.1989	128
Berkåk - Lyngholt	SN66730	03.1990	90
Berkåk - Lyngholt	SN66730	03.1991	40

Berkåk - Lyngholt	SN66730	03.1992	88
Berkåk - Lyngholt	SN66730	03.1993	115
Berkåk - Lyngholt	SN66730	03.1994	65
Berkåk - Lyngholt	SN66730	03.1995	105
Berkåk - Lyngholt	SN66730	03.1996	108
Berkåk - Lyngholt	SN66730	03.1997	134
Berkåk - Lyngholt	SN66730	03.1998	105
Berkåk - Lyngholt	SN66730	03.1999	73
Berkåk - Lyngholt	SN66730	03.2000	167
Berkåk - Lyngholt	SN66730	03.2001	81
Berkåk - Lyngholt	SN66730	03.2002	145
Berkåk - Lyngholt	SN66730	03.2003	64
Berkåk - Lyngholt	SN66730	03.2004	109
Berkåk - Lyngholt	SN66730	03.2005	149
Berkåk - Lyngholt	SN66730	03.2006	110
Berkåk - Lyngholt	SN66730	03.2008	135
Berkåk - Lyngholt	SN66730	12.1985	87
Berkåk - Lyngholt	SN66730	12.1986	40
Berkåk - Lyngholt	SN66730	12.1988	95
Berkåk - Lyngholt	SN66730	12.1989	75
Berkåk - Lyngholt	SN66730	12.1990	25
Berkåk - Lyngholt	SN66730	12.1991	65
Berkåk - Lyngholt	SN66730	12.1992	30
Berkåk - Lyngholt	SN66730	12.1993	33
Berkåk - Lyngholt	SN66730	12.1994	58
Berkåk - Lyngholt	SN66730	12.1995	69
Berkåk - Lyngholt	SN66730	12.1996	80
Berkåk - Lyngholt	SN66730	12.1997	38
Berkåk - Lyngholt	SN66730	12.1998	52
Berkåk - Lyngholt	SN66730	12.1999	85
Berkåk - Lyngholt	SN66730	12.2000	48
Berkåk - Lyngholt	SN66730	12.2001	85
Berkåk - Lyngholt	SN66730	12.2002	45
Berkåk - Lyngholt	SN66730	12.2003	90
Berkåk - Lyngholt	SN66730	12.2004	90
Berkåk - Lyngholt	SN66730	12.2005	80
Berkåk - Lyngholt	SN66730	12.2007	83
Byneset	SN68000	01.1986	72
Byneset	SN68000	01.1987	35
Byneset	SN68000	01.1989	28
Byneset	SN68000	01.1990	16
Byneset	SN68000	01.1991	10
Byneset	SN68000	01.1992	20
Byneset	SN68000	01.1993	31
Byneset	SN68000	01.1994	38
Byneset	SN68000	01.1995	25
Byneset	SN68000	01.1996	62
Byneset	SN68000	01.1997	21
Byneset	SN68000	01.1998	22
Byneset	SN68000	01.1999	13
Byneset	SN68000	01.2000	22
Byneset	SN68000	01.2001	16
Byneset	SN68000	01.2002	45
Byneset	SN68000	01.2003	30

Byneset	SN68000	01.2004	20
Byneset	SN68000	02.1986	71
Byneset	SN68000	02.1987	38
Byneset	SN68000	02.1989	23
Byneset	SN68000	02.1990	10
Byneset	SN68000	02.1991	28
Byneset	SN68000	02.1992	13
Byneset	SN68000	02.1993	48
Byneset	SN68000	02.1994	24
Byneset	SN68000	02.1995	36
Byneset	SN68000	02.1996	30
Byneset	SN68000	02.1997	22
Byneset	SN68000	02.1998	35
Byneset	SN68000	02.1999	21
Byneset	SN68000	02.2000	26
Byneset	SN68000	02.2001	18
Byneset	SN68000	02.2002	55
Byneset	SN68000	02.2003	5
Byneset	SN68000	02.2004	40
Byneset	SN68000	03.1986	77
Byneset	SN68000	03.1987	32
Byneset	SN68000	03.1989	16
Byneset	SN68000	03.1990	23
Byneset	SN68000	03.1991	14
Byneset	SN68000	03.1992	21
Byneset	SN68000	03.1993	38
Byneset	SN68000	03.1994	21
Byneset	SN68000	03.1995	26
Byneset	SN68000	03.1996	28
Byneset	SN68000	03.1997	34
Byneset	SN68000	03.1998	36
Byneset	SN68000	03.1999	20
Byneset	SN68000	03.2000	44
Byneset	SN68000	03.2001	18
Byneset	SN68000	03.2002	83
Byneset	SN68000	03.2003	3
Byneset	SN68000	03.2004	13
Byneset	SN68000	12.1985	41
Byneset	SN68000	12.1986	22
Byneset	SN68000	12.1988	28
Byneset	SN68000	12.1989	23
Byneset	SN68000	12.1990	10
Byneset	SN68000	12.1991	34
Byneset	SN68000	12.1992	13
Byneset	SN68000	12.1993	24
Byneset	SN68000	12.1994	8
Byneset	SN68000	12.1995	63
Byneset	SN68000	12.1996	35
Byneset	SN68000	12.1997	14
Byneset	SN68000	12.1998	21
Byneset	SN68000	12.1999	60
Byneset	SN68000	12.2000	26
Byneset	SN68000	12.2001	24
Byneset	SN68000	12.2002	8

Byneset	SN68000	12.2003	20
Byneset	SN68000	12.2004	34
Endalsvoll	SN67450	01.1986	98
Endalsvoll	SN67450	01.1987	80
Endalsvoll	SN67450	01.1989	124
Endalsvoll	SN67450	01.1990	86
Endalsvoll	SN67450	01.1991	23
Endalsvoll	SN67450	01.1992	96
Endalsvoll	SN67450	01.1993	68
Endalsvoll	SN67450	01.1994	71
Endalsvoll	SN67450	01.1995	84
Endalsvoll	SN67450	01.1996	44
Endalsvoll	SN67450	01.1997	76
Endalsvoll	SN67450	01.1998	110
Endalsvoll	SN67450	01.1999	52
Endalsvoll	SN67450	01.2000	137
Endalsvoll	SN67450	01.2001	55
Endalsvoll	SN67450	01.2002	110
Endalsvoll	SN67450	01.2003	78
Endalsvoll	SN67450	01.2004	92
Endalsvoll	SN67450	02.1986	95
Endalsvoll	SN67450	02.1987	122
Endalsvoll	SN67450	02.1989	127
Endalsvoll	SN67450	02.1990	74
Endalsvoll	SN67450	02.1991	48
Endalsvoll	SN67450	02.1992	95
Endalsvoll	SN67450	02.1993	115
Endalsvoll	SN67450	02.1994	78
Endalsvoll	SN67450	02.1995	109
Endalsvoll	SN67450	02.1996	62
Endalsvoll	SN67450	02.1997	93
Endalsvoll	SN67450	02.1998	112
Endalsvoll	SN67450	02.1999	88
Endalsvoll	SN67450	02.2000	150
Endalsvoll	SN67450	02.2001	97
Endalsvoll	SN67450	02.2002	124
Endalsvoll	SN67450	02.2003	76
Endalsvoll	SN67450	02.2004	125
Endalsvoll	SN67450	03.1986	93
Endalsvoll	SN67450	03.1987	110
Endalsvoll	SN67450	03.1989	116
Endalsvoll	SN67450	03.1990	110
Endalsvoll	SN67450	03.1991	36
Endalsvoll	SN67450	03.1992	100
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Endalsvoll	SN67450	03.1994	78
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Endalsvoll	SN67450	03.1996	88
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Endalsvoll	SN67450	03.1998	132
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Endalsvoll	SN67450	03.2002	155
Endalsvoll	SN67450	03.2003	75

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Endalsvoll	SN67450	12.1985	68
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Hemne	SN65220	01.1996	98
Hemne	SN65220	01.1997	29
Hemne	SN65220	01.1998	56
Hemne	SN65220	02.1986	142
Hemne	SN65220	02.1987	100
Hemne	SN65220	02.1989	51
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Hemne	SN65220	02.1994	96
Hemne	SN65220	02.1995	110
Hemne	SN65220	02.1996	74
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Hemne	SN65220	03.1995	96
Hemne	SN65220	03.1996	77
Hemne	SN65220	03.1997	63

Hemne	SN65220	03.1998	83
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Hølonda	SN66250	03.1995	130
Hølonda	SN66250	03.1996	72
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Hølonda	SN66250	12.1999	105
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Lensvik	SN66030	01.1993	31
Lensvik	SN66030	01.1994	50
Lensvik	SN66030	01.1995	35
Lensvik	SN66030	01.1996	70
Lensvik	SN66030	01.1997	29
Lensvik	SN66030	01.1998	17
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Lensvik	SN66030	01.2000	27
Lensvik	SN66030	01.2001	28
Lensvik	SN66030	01.2002	36
Lensvik	SN66030	01.2003	41
Lensvik	SN66030	01.2004	37
Lensvik	SN66030	01.2005	34
Lensvik	SN66030	02.1986	68
Lensvik	SN66030	02.1987	32
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Lensvik	SN66030	02.1992	32
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Lensvik	SN66030	02.1994	72
Lensvik	SN66030	02.1995	55
Lensvik	SN66030	02.1996	74
Lensvik	SN66030	02.1997	38
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Lensvik	SN66030	02.1999	32
Lensvik	SN66030	02.2000	37
Lensvik	SN66030	02.2001	35
Lensvik	SN66030	02.2002	59
Lensvik	SN66030	02.2003	16
Lensvik	SN66030	02.2004	46

Lensvik	SN66030	02.2005	23
Lensvik	SN66030	02.2006	37
Lensvik	SN66030	03.1986	69
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Lensvik	SN66030	12.1989	26
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Lensvik	SN66030	12.1992	9
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Lensvik	SN66030	12.1999	64
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Lensvik	SN66030	12.2002	11
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Lensvik	SN66030	12.2004	41
Lensvik	SN66030	12.2005	27
Løksmyr	SN68270	01.1986	98
Løksmyr	SN68270	01.1987	35
Løksmyr	SN68270	01.1989	51
Løksmyr	SN68270	01.1990	51
Løksmyr	SN68270	01.1991	13
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Løksmyr	SN68270	01.1993	36
Løksmyr	SN68270	01.1994	68
Løksmyr	SN68270	01.1995	58
Løksmyr	SN68270	01.1996	74
Løksmyr	SN68270	01.1997	66
Løksmyr	SN68270	01.1998	34

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Løksmyr	SN68270	01.2001	32
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Løksmyr	SN68270	01.2003	41
Løksmyr	SN68270	01.2004	43
Løksmyr	SN68270	01.2005	70
Løksmyr	SN68270	01.2006	26
Løksmyr	SN68270	01.2008	30
Løksmyr	SN68270	01.2009	116
Løksmyr	SN68270	01.2010	38
Løksmyr	SN68270	01.2011	80
Løksmyr	SN68270	01.2012	69
Løksmyr	SN68270	01.2013	11
Løksmyr	SN68270	01.2014	2
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Løksmyr	SN68270	01.2016	55
Løksmyr	SN68270	01.2017	47
Løksmyr	SN68270	01.2018	40
Løksmyr	SN68270	01.2019	87
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Løksmyr	SN68270	02.1995	85
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Løksmyr	SN68270	03.2009	98
Løksmyr	SN68270	03.2010	91
Løksmyr	SN68270	03.2011	83
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Lundamo	SN67200	03.1986	67
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Lundamo	SN67200	03.1989	21
Lundamo	SN67200	03.1990	40
Lundamo	SN67200	03.1991	15
Lundamo	SN67200	03.1992	20
Lundamo	SN67200	03.1993	32
Lundamo	SN67200	03.1994	46
Lundamo	SN67200	03.1995	28
Lundamo	SN67200	03.1996	50
Lundamo	SN67200	03.1997	40

Lundamo	SN67200	03.1998	45
Lundamo	SN67200	03.1999	19
Lundamo	SN67200	03.2000	58
Lundamo	SN67200	03.2001	32
Lundamo	SN67200	03.2002	85
Lundamo	SN67200	12.1985	45
Lundamo	SN67200	12.1986	20
Lundamo	SN67200	12.1988	65
Lundamo	SN67200	12.1989	30
Lundamo	SN67200	12.1990	10
Lundamo	SN67200	12.1991	35
Lundamo	SN67200	12.1992	16
Lundamo	SN67200	12.1993	32
Lundamo	SN67200	12.1994	10
Lundamo	SN67200	12.1995	75
Lundamo	SN67200	12.1996	54
Lundamo	SN67200	12.1997	12
Lundamo	SN67200	12.1998	28
Lundamo	SN67200	12.1999	60
Lundamo	SN67200	12.2000	20
Lundamo	SN67200	12.2001	18
Nerskogen Ii	SN66580	01.1986	106
Nerskogen Ii	SN66580	01.1987	120
Nerskogen Ii	SN66580	01.1989	175
Nerskogen Ii	SN66580	01.1990	117
Nerskogen Ii	SN66580	01.1991	38
Nerskogen Ii	SN66580	01.1992	105
Nerskogen Ii	SN66580	01.1993	90
Nerskogen Ii	SN66580	01.1994	82
Nerskogen Ii	SN66580	01.1995	105
Nerskogen Ii	SN66580	01.1996	58
Nerskogen Ii	SN66580	01.1997	81
Nerskogen Ii	SN66580	01.1998	61
Nerskogen Ii	SN66580	01.1999	67
Nerskogen Ii	SN66580	01.2000	187
Nerskogen Ii	SN66580	01.2001	62
Nerskogen Ii	SN66580	01.2002	132
Nerskogen Ii	SN66580	01.2003	123
Nerskogen Ii	SN66580	01.2004	72
Nerskogen Ii	SN66580	01.2005	175
Nerskogen Ii	SN66580	01.2006	79
Nerskogen Ii	SN66580	01.2007	125
Nerskogen Ii	SN66580	01.2008	95
Nerskogen Ii	SN66580	01.2009	83
Nerskogen Ii	SN66580	02.1986	95
Nerskogen Ii	SN66580	02.1987	185
Nerskogen Ii	SN66580	02.1989	190
Nerskogen Ii	SN66580	02.1990	112
Nerskogen Ii	SN66580	02.1991	50
Nerskogen Ii	SN66580	02.1992	103
Nerskogen Ii	SN66580	02.1993	138
Nerskogen Ii	SN66580	02.1994	87
Nerskogen Ii	SN66580	02.1995	154
Nerskogen Ii	SN66580	02.1996	87

Nerskogen Ii	SN66580	02.1997	100
Nerskogen Ii	SN66580	02.1998	68
Nerskogen Ii	SN66580	02.1999	89
Nerskogen Ii	SN66580	02.2000	195
Nerskogen Ii	SN66580	02.2001	93
Nerskogen Ii	SN66580	02.2002	132
Nerskogen Ii	SN66580	02.2003	123
Nerskogen Ii	SN66580	02.2004	87
Nerskogen Ii	SN66580	02.2006	94
Nerskogen Ii	SN66580	02.2007	136
Nerskogen Ii	SN66580	02.2008	108
Nerskogen Ii	SN66580	02.2009	82
Nerskogen Ii	SN66580	03.1986	93
Nerskogen Ii	SN66580	03.1987	185
Nerskogen Ii	SN66580	03.1989	185
Nerskogen Ii	SN66580	03.1990	115
Nerskogen Ii	SN66580	03.1991	50
Nerskogen Ii	SN66580	03.1992	115
Nerskogen Ii	SN66580	03.1993	174
Nerskogen Ii	SN66580	03.1994	100
Nerskogen Ii	SN66580	03.1995	166
Nerskogen Ii	SN66580	03.1996	98
Nerskogen Ii	SN66580	03.1997	150
Nerskogen Ii	SN66580	03.1998	98
Nerskogen Ii	SN66580	03.1999	91
Nerskogen Ii	SN66580	03.2000	230
Nerskogen Ii	SN66580	03.2001	102
Nerskogen Ii	SN66580	03.2002	176
Nerskogen Ii	SN66580	03.2003	124
Nerskogen Ii	SN66580	03.2004	92
Nerskogen Ii	SN66580	03.2006	104
Nerskogen Ii	SN66580	03.2007	146
Nerskogen Ii	SN66580	03.2008	167
Nerskogen Ii	SN66580	03.2009	93
Nerskogen Ii	SN66580	12.1985	83
Nerskogen Ii	SN66580	12.1986	48
Nerskogen Ii	SN66580	12.1988	151
Nerskogen Ii	SN66580	12.1989	113
Nerskogen Ii	SN66580	12.1990	48
Nerskogen Ii	SN66580	12.1991	88
Nerskogen Ii	SN66580	12.1992	53
Nerskogen Ii	SN66580	12.1993	30
Nerskogen Ii	SN66580	12.1994	73
Nerskogen Ii	SN66580	12.1995	58
Nerskogen Ii	SN66580	12.1996	70
Nerskogen Ii	SN66580	12.1997	41
Nerskogen Ii	SN66580	12.1998	63
Nerskogen Ii	SN66580	12.1999	81
Nerskogen Ii	SN66580	12.2000	38
Nerskogen Ii	SN66580	12.2001	112
Nerskogen Ii	SN66580	12.2002	54
Nerskogen Ii	SN66580	12.2003	70
Nerskogen Ii	SN66580	12.2004	115
Nerskogen Ii	SN66580	12.2005	73

Nerskogen Ii	SN66580	12.2006	51
Nerskogen Ii	SN66580	12.2007	80
Nerskogen Ii	SN66580	12.2008	71
Rindal	SN64900	01.1986	125
Rindal	SN64900	01.1987	63
Rindal	SN64900	01.1989	50
Rindal	SN64900	01.1990	36
Rindal	SN64900	01.1991	22
Rindal	SN64900	01.1992	65
Rindal	SN64900	01.1993	74
Rindal	SN64900	01.1994	107
Rindal	SN64900	01.1995	90
Rindal	SN64900	01.1996	78
Rindal	SN64900	01.1997	65
Rindal	SN64900	01.1998	48
Rindal	SN64900	01.1999	46
Rindal	SN64900	01.2000	50
Rindal	SN64900	01.2001	61
Rindal	SN64900	01.2002	50
Rindal	SN64900	01.2003	39
Rindal	SN64900	01.2004	53
Rindal	SN64900	01.2005	94
Rindal	SN64900	01.2007	98
Rindal	SN64900	01.2008	41
Rindal	SN64900	01.2009	65
Rindal	SN64900	01.2011	105
Rindal	SN64900	01.2012	71
Rindal	SN64900	01.2016	76
Rindal	SN64900	02.1986	124
Rindal	SN64900	02.1987	102
Rindal	SN64900	02.1989	52
Rindal	SN64900	02.1990	45
Rindal	SN64900	02.1991	26
Rindal	SN64900	02.1992	38
Rindal	SN64900	02.1993	96
Rindal	SN64900	02.1994	78
Rindal	SN64900	02.1995	100
Rindal	SN64900	02.1996	75
Rindal	SN64900	02.1997	50
Rindal	SN64900	02.1998	45
Rindal	SN64900	02.1999	59
Rindal	SN64900	02.2000	56
Rindal	SN64900	02.2001	55
Rindal	SN64900	02.2002	67
Rindal	SN64900	02.2003	15
Rindal	SN64900	02.2004	56
Rindal	SN64900	02.2005	63
Rindal	SN64900	02.2006	45
Rindal	SN64900	02.2007	75
Rindal	SN64900	02.2008	43
Rindal	SN64900	02.2010	77
Rindal	SN64900	02.2011	70
Rindal	SN64900	02.2013	52
Rindal	SN64900	02.2014	11

Rindal	SN64900	02.2015	48
Rindal	SN64900	02.2016	150
Rindal	SN64900	03.1986	128
Rindal	SN64900	03.1987	100
Rindal	SN64900	03.1989	42
Rindal	SN64900	03.1990	88
Rindal	SN64900	03.1991	22
Rindal	SN64900	03.1992	50
Rindal	SN64900	03.1993	116
Rindal	SN64900	03.1994	80
Rindal	SN64900	03.1995	99
Rindal	SN64900	03.1996	74
Rindal	SN64900	03.1997	54
Rindal	SN64900	03.1998	54
Rindal	SN64900	03.1999	66
Rindal	SN64900	03.2000	92
Rindal	SN64900	03.2001	45
Rindal	SN64900	03.2002	105
Rindal	SN64900	03.2003	12
Rindal	SN64900	03.2004	32
Rindal	SN64900	03.2005	64
Rindal	SN64900	03.2006	60
Rindal	SN64900	03.2007	61
Rindal	SN64900	03.2008	74
Rindal	SN64900	03.2009	51
Rindal	SN64900	03.2010	88
Rindal	SN64900	03.2011	73
Rindal	SN64900	03.2012	37
Rindal	SN64900	03.2014	43
Rindal	SN64900	03.2015	10
Rindal	SN64900	03.2016	150
Rindal	SN64900	12.1985	110
Rindal	SN64900	12.1986	36
Rindal	SN64900	12.1988	81
Rindal	SN64900	12.1989	44
Rindal	SN64900	12.1990	15
Rindal	SN64900	12.1991	81
Rindal	SN64900	12.1992	38
Rindal	SN64900	12.1993	61
Rindal	SN64900	12.1994	30
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Rindal	SN64900	12.1997	18
Rindal	SN64900	12.1998	39
Rindal	SN64900	12.1999	59
Rindal	SN64900	12.2000	60
Rindal	SN64900	12.2001	49
Rindal	SN64900	12.2002	19
Rindal	SN64900	12.2003	43
Rindal	SN64900	12.2004	60
Rindal	SN64900	12.2006	28
Rindal	SN64900	12.2007	31
Rindal	SN64900	12.2009	30
Rindal	SN64900	12.2010	66

Rindal	SN64900	12.2011	34
Rindal	SN64900	12.2012	28
Rindal	SN64900	12.2013	68
Rindal	SN64900	12.2014	78
Rindal	SN64900	12.2015	15
Selva	SN66010	01.1991	20
Selva	SN66010	01.1992	11
Selva	SN66010	01.1993	2
Selva	SN66010	02.1991	14
Selva	SN66010	02.1992	0
Selva	SN66010	02.1993	40
Selva	SN66010	03.1991	4
Selva	SN66010	03.1992	10
Selva	SN66010	03.1993	35
Selva	SN66010	12.1990	7
Selva	SN66010	12.1991	30
Selva	SN66010	12.1992	5
Skjenaldfossen I Orkdal	SN66070	01.1986	128
Skjenaldfossen I Orkdal	SN66070	01.1987	72
Skjenaldfossen I Orkdal	SN66070	01.1989	69
Skjenaldfossen I Orkdal	SN66070	01.1990	49
Skjenaldfossen I Orkdal	SN66070	01.1991	15
Skjenaldfossen I Orkdal	SN66070	01.1992	52
Skjenaldfossen I Orkdal	SN66070	01.1993	68
Skjenaldfossen I Orkdal	SN66070	01.1994	93
Skjenaldfossen I Orkdal	SN66070	01.1995	80
Skjenaldfossen I Orkdal	SN66070	01.1996	68
Skjenaldfossen I Orkdal	SN66070	01.1997	55
Skjenaldfossen I Orkdal	SN66070	01.1998	71
Skjenaldfossen I Orkdal	SN66070	01.1999	40
Skjenaldfossen I Orkdal	SN66070	01.2000	67
Skjenaldfossen I Orkdal	SN66070	01.2001	48
Skjenaldfossen I Orkdal	SN66070	01.2002	45
Skjenaldfossen I Orkdal	SN66070	01.2003	42
Skjenaldfossen I Orkdal	SN66070	01.2004	69
Skjenaldfossen I Orkdal	SN66070	01.2005	95
Skjenaldfossen I Orkdal	SN66070	01.2006	53
Skjenaldfossen I Orkdal	SN66070	01.2008	51
Skjenaldfossen I Orkdal	SN66070	01.2009	95
Skjenaldfossen I Orkdal	SN66070	01.2010	55
Skjenaldfossen I Orkdal	SN66070	01.2011	95
Skjenaldfossen I Orkdal	SN66070	01.2012	63
Skjenaldfossen I Orkdal	SN66070	01.2013	37
Skjenaldfossen I Orkdal	SN66070	02.1986	125
Skjenaldfossen I Orkdal	SN66070	02.1987	92
Skjenaldfossen I Orkdal	SN66070	02.1989	84
Skjenaldfossen I Orkdal	SN66070	02.1990	55
Skjenaldfossen I Orkdal	SN66070	02.1991	65
Skjenaldfossen I Orkdal	SN66070	02.1992	30
Skjenaldfossen I Orkdal	SN66070	02.1993	118
Skjenaldfossen I Orkdal	SN66070	02.1994	103
Skjenaldfossen I Orkdal	SN66070	02.1995	112
Skjenaldfossen I Orkdal	SN66070	02.1996	80
Skjenaldfossen I Orkdal	SN66070	02.1997	70

Skjenaldfossen I Orkdal	SN66070	02.1998	78
Skjenaldfossen I Orkdal	SN66070	02.1999	65
Skjenaldfossen I Orkdal	SN66070	02.2000	97
Skjenaldfossen I Orkdal	SN66070	02.2001	45
Skjenaldfossen I Orkdal	SN66070	02.2002	77
Skjenaldfossen I Orkdal	SN66070	02.2003	28
Skjenaldfossen I Orkdal	SN66070	02.2004	71
Skjenaldfossen I Orkdal	SN66070	02.2005	88
Skjenaldfossen I Orkdal	SN66070	02.2006	60
Skjenaldfossen I Orkdal	SN66070	02.2007	70
Skjenaldfossen I Orkdal	SN66070	02.2008	60
Skjenaldfossen I Orkdal	SN66070	02.2009	102
Skjenaldfossen I Orkdal	SN66070	02.2010	59
Skjenaldfossen I Orkdal	SN66070	02.2011	63
Skjenaldfossen I Orkdal	SN66070	02.2012	109
Skjenaldfossen I Orkdal	SN66070	02.2013	56
Skjenaldfossen I Orkdal	SN66070	02.2014	13
Skjenaldfossen I Orkdal	SN66070	02.2016	90
Skjenaldfossen I Orkdal	SN66070	02.2017	45
Skjenaldfossen I Orkdal	SN66070	03.1986	123
Skjenaldfossen I Orkdal	SN66070	03.1987	95
Skjenaldfossen I Orkdal	SN66070	03.1989	76
Skjenaldfossen I Orkdal	SN66070	03.1990	97
Skjenaldfossen I Orkdal	SN66070	03.1991	41
Skjenaldfossen I Orkdal	SN66070	03.1992	55
Skjenaldfossen I Orkdal	SN66070	03.1993	110
Skjenaldfossen I Orkdal	SN66070	03.1994	102
Skjenaldfossen I Orkdal	SN66070	03.1995	118
Skjenaldfossen I Orkdal	SN66070	03.1996	94
Skjenaldfossen I Orkdal	SN66070	03.1997	100
Skjenaldfossen I Orkdal	SN66070	03.1998	56
Skjenaldfossen I Orkdal	SN66070	03.1999	76
Skjenaldfossen I Orkdal	SN66070	03.2000	135
Skjenaldfossen I Orkdal	SN66070	03.2001	34
Skjenaldfossen I Orkdal	SN66070	03.2002	95
Skjenaldfossen I Orkdal	SN66070	03.2003	25
Skjenaldfossen I Orkdal	SN66070	03.2004	52
Skjenaldfossen I Orkdal	SN66070	03.2005	91
Skjenaldfossen I Orkdal	SN66070	03.2006	59
Skjenaldfossen I Orkdal	SN66070	03.2007	50
Skjenaldfossen I Orkdal	SN66070	03.2008	87
Skjenaldfossen I Orkdal	SN66070	03.2009	105
Skjenaldfossen I Orkdal	SN66070	03.2010	78
Skjenaldfossen I Orkdal	SN66070	03.2011	95
Skjenaldfossen I Orkdal	SN66070	03.2012	81
Skjenaldfossen I Orkdal	SN66070	03.2013	74
Skjenaldfossen I Orkdal	SN66070	03.2017	40
Skjenaldfossen I Orkdal	SN66070	12.1985	112
Skjenaldfossen I Orkdal	SN66070	12.1986	47
Skjenaldfossen I Orkdal	SN66070	12.1988	72
Skjenaldfossen I Orkdal	SN66070	12.1989	38
Skjenaldfossen I Orkdal	SN66070	12.1990	15
Skjenaldfossen I Orkdal	SN66070	12.1991	55
Skjenaldfossen I Orkdal	SN66070	12.1992	38

Skjenaldfossen I Orkdal	SN66070	12.1993	50
Skjenaldfossen I Orkdal	SN66070	12.1994	22
Skjenaldfossen I Orkdal	SN66070	12.1995	76
Skjenaldfossen I Orkdal	SN66070	12.1996	67
Skjenaldfossen I Orkdal	SN66070	12.1997	35
Skjenaldfossen I Orkdal	SN66070	12.1998	35
Skjenaldfossen I Orkdal	SN66070	12.1999	87
Skjenaldfossen I Orkdal	SN66070	12.2000	48
Skjenaldfossen I Orkdal	SN66070	12.2001	40
Skjenaldfossen I Orkdal	SN66070	12.2002	14
Skjenaldfossen I Orkdal	SN66070	12.2003	60
Skjenaldfossen I Orkdal	SN66070	12.2004	50
Skjenaldfossen I Orkdal	SN66070	12.2005	40
Skjenaldfossen I Orkdal	SN66070	12.2006	21
Skjenaldfossen I Orkdal	SN66070	12.2007	26
Skjenaldfossen I Orkdal	SN66070	12.2008	41
Skjenaldfossen I Orkdal	SN66070	12.2009	15
Skjenaldfossen I Orkdal	SN66070	12.2010	61
Skjenaldfossen I Orkdal	SN66070	12.2011	31
Skjenaldfossen I Orkdal	SN66070	12.2012	33
Soknedal	SN67280	01.2008	76
Soknedal	SN67280	01.2010	44
Soknedal	SN67280	01.2011	81
Soknedal	SN67280	01.2012	102
Soknedal	SN67280	01.2013	20
Soknedal	SN67280	01.2014	35
Soknedal	SN67280	01.2015	73
Soknedal	SN67280	01.2017	77
Soknedal	SN67280	01.2018	54
Soknedal	SN67280	01.2019	55
Soknedal	SN67280	02.2010	61
Soknedal	SN67280	02.2012	107
Soknedal	SN67280	02.2013	44
Soknedal	SN67280	02.2014	31
Soknedal	SN67280	02.2015	59
Soknedal	SN67280	02.2016	70
Soknedal	SN67280	02.2017	89
Soknedal	SN67280	02.2018	61
Soknedal	SN67280	02.2019	52
Soknedal	SN67280	03.2009	99
Soknedal	SN67280	03.2010	67
Soknedal	SN67280	03.2013	66
Soknedal	SN67280	03.2014	53
Soknedal	SN67280	03.2015	48
Soknedal	SN67280	03.2016	64
Soknedal	SN67280	03.2017	90
Soknedal	SN67280	03.2018	78
Soknedal	SN67280	03.2019	60
Soknedal	SN67280	12.2009	22
Soknedal	SN67280	12.2010	49
Soknedal	SN67280	12.2012	22
Soknedal	SN67280	12.2013	52
Soknedal	SN67280	12.2014	52
Soknedal	SN67280	12.2016	47

Songli	SN66100	01.1986	176
Songli	SN66100	01.1987	76
Songli	SN66100	01.1989	111
Songli	SN66100	01.1990	75
Songli	SN66100	01.1991	18
Songli	SN66100	01.1992	76
Songli	SN66100	01.1993	86
Songli	SN66100	01.1994	94
Songli	SN66100	01.1995	112
Songli	SN66100	01.1996	87
Songli	SN66100	01.1997	97
Songli	SN66100	01.1998	86
Songli	SN66100	01.1999	47
Songli	SN66100	01.2000	97
Songli	SN66100	01.2001	51
Songli	SN66100	01.2002	52
Songli	SN66100	01.2003	74
Songli	SN66100	01.2004	85
Songli	SN66100	01.2006	65
Songli	SN66100	01.2010	56
Songli	SN66100	01.2011	100
Songli	SN66100	02.1986	165
Songli	SN66100	02.1987	129
Songli	SN66100	02.1989	152
Songli	SN66100	02.1990	66
Songli	SN66100	02.1991	63
Songli	SN66100	02.1992	76
Songli	SN66100	02.1993	136
Songli	SN66100	02.1994	100
Songli	SN66100	02.1995	160
Songli	SN66100	02.1996	105
Songli	SN66100	02.1997	104
Songli	SN66100	02.1998	98
Songli	SN66100	02.1999	77
Songli	SN66100	02.2000	148
Songli	SN66100	02.2001	77
Songli	SN66100	02.2002	118
Songli	SN66100	02.2003	68
Songli	SN66100	02.2004	90
Songli	SN66100	02.2006	86
Songli	SN66100	02.2007	85
Songli	SN66100	02.2008	100
Songli	SN66100	02.2010	77
Songli	SN66100	03.1986	176
Songli	SN66100	03.1987	120
Songli	SN66100	03.1989	137
Songli	SN66100	03.1990	132
Songli	SN66100	03.1991	49
Songli	SN66100	03.1992	88
Songli	SN66100	03.1993	136
Songli	SN66100	03.1994	109
Songli	SN66100	03.1995	162
Songli	SN66100	03.1996	110
Songli	SN66100	03.1997	135

Songli	SN66100	03.1998	118
Songli	SN66100	03.1999	95
Songli	SN66100	03.2000	192
Songli	SN66100	03.2001	78
Songli	SN66100	03.2002	140
Songli	SN66100	03.2003	67
Songli	SN66100	03.2004	71
Songli	SN66100	03.2006	84
Songli	SN66100	03.2007	95
Songli	SN66100	03.2008	138
Songli	SN66100	03.2010	111
Songli	SN66100	03.2011	138
Songli	SN66100	12.1985	166
Songli	SN66100	12.1986	45
Songli	SN66100	12.1988	100
Songli	SN66100	12.1989	59
Songli	SN66100	12.1990	25
Songli	SN66100	12.1991	66
Songli	SN66100	12.1992	41
Songli	SN66100	12.1993	53
Songli	SN66100	12.1994	45
Songli	SN66100	12.1995	100
Songli	SN66100	12.1996	72
Songli	SN66100	12.1997	35
Songli	SN66100	12.1998	47
Songli	SN66100	12.1999	90
Songli	SN66100	12.2000	45
Songli	SN66100	12.2001	42
Songli	SN66100	12.2002	23
Songli	SN66100	12.2003	65
Songli	SN66100	12.2004	75
Songli	SN66100	12.2009	21
Songli	SN66100	12.2011	43
Tågdalen	SN64870	01.2008	99
Tågdalen	SN64870	01.2009	112
Tågdalen	SN64870	01.2010	83
Tågdalen	SN64870	01.2013	44
Tågdalen	SN64870	01.2017	93
Tågdalen	SN64870	01.2018	194
Tågdalen	SN64870	02.2012	0
Tågdalen	SN64870	02.2013	82
Tågdalen	SN64870	02.2014	44
Tågdalen	SN64870	02.2017	67
Tågdalen	SN64870	02.2019	87
Tågdalen	SN64870	03.2008	159
Tågdalen	SN64870	03.2009	110
Tågdalen	SN64870	03.2010	133
Tågdalen	SN64870	03.2012	0
Tågdalen	SN64870	03.2013	124
Tågdalen	SN64870	03.2014	64
Tågdalen	SN64870	03.2015	73
Tågdalen	SN64870	03.2017	92
Tågdalen	SN64870	03.2018	202
Tågdalen	SN64870	03.2019	92

Tågdalen	SN64870	12.2007	62
Tågdalen	SN64870	12.2008	55
Tågdalen	SN64870	12.2009	42
Tågdalen	SN64870	12.2012	45
Tågdalen	SN64870	12.2016	67

Annex 6: North Atlantic Oscillation Index (NAOI) per month collected for the study period (1986-2019). The winter NAOI used for the data analyses correspond at the mean NAOI from December$_{\text{Year−1}}$ to March$_{\text{Year}}$.

Year	January	February	March	December
1985	N/A*	N/A*	N/A*	-1.2
1986	2.4	-2.7	3.9	1.9
1987	-3.5	-0.7	-0.1	N/A*
1988	N/A*	N/A*	N/A*	0.5
1989	2.4	3.2	3.2	-3.4
1990	3	3.2	2.3	1.1
1991	0.7	0.5	-0.1	0.2
1992	-1	2	2	1.2
1993	2.1	0.3	1.2	2.6
1994	2	-0.4	4.4	1.6
1995	1.4	2.3	1.8	-3.8
1996	-1.8	0.9	-2.6	-3.6
1997	-2.4	3.7	1.2	-0.5
1998	-0.7	0.7	0.5	1.6
1999	1.3	2.2	0.2	1.7
2000	0.1	3.1	0.4	-2.2
2001	-0.1	-0.5	-1.5	-4.1
2002	0.5	1.7	0.9	-2.4
2003	0.4	1.2	0.5	-1.1
2004	0.2	-1.4	1.5	2.6
2005	1	-0.6	-3	-0.7
2006	1	-0.7	-1.8	2.1
2007	1.1	-0.2	3.1	0.9
2008	1.4	0.4	1.6	0.5
2009	1.6	-0.2	1.7	-4.6
2010	-1.9	-3.6	-1.5	-5.6
2011	-1.3	1.9	0.4	3.5
2012	1.7	1.3	0.9	-0.4
2013	0.8	0.1	-4.3	2.8
2014	2	2.2	2.2	2.9
2015	3.5	2.4	3.1	N/A*
2016	N/A*	N/A*	N/A*	0.9
2017	-0.4	1.2	1.5	0.8
2018	2.4	0.9	-1	0.1
2019	0.1	0.1	2.6	0.8

*The data were available but as no eggs were sampled for the year 1988 and 2016. only the data for December were kept and used to calculate the NAOI for Year+1

Annex 7: Correlation matrices using Pearson test for year, temperature, max snow depth (Max_Snow), North Atlantic Oscillation index (NAOI), mercury concentration dry weight (HgDw) (non- and *ln*-transformed), mercury concentration wet weight (HgWw), stable carbon isotope value (∂^{13}C), and stable nitrogen isotope value (∂^{15}N) for the entire period (1986-2019).

Parameter 1	Parameter 2	r	95% CI	t	p
Year	Temperature	-0.04	[-0.17, 0.09]	-0.58	> 0.999
Year	Max_Snow	0.07	[-0.06, 0.20]	1.07	> 0.999
Year	NAOI	0.00426	[-0.13, 0.14]	0.06	> 0.999
Year	HgDw	-0.33	[-0.44, -0.20]	-5.14	< 0.001***
Year	HgWw	-0.30	[-0.42, -0.18]	-4.72	< 0.001***
Year	∂^{13}C	-0.43	[-0.53, -0.31]	-7.04	< 0.001***
Year	∂^{15}N	-0.06	[-0.19, 0.07]	-0.86	> 0.999
Year	lnHgDw	-0.34	[-0.45, -0.22]	-5.42	< 0.001***
Temperature	Max_Snow	-0.27	[-0.38, -0.14]	-4.11	0.001**
Temperature	NAOI	0.59	[0.49, 0.67]	10.77	< 0.001***
Temperature	HgDw	-0.23	[-0.35, -0.11]	-3.59	0.009**
Temperature	HgWw	-0.26	[-0.37, -0.13]	0.95	0.002**
Temperature	∂^{13}C	0.06	[-0.07, 0.19]	-1.60	> 0.999
Temperature	∂^{15}N	-0.11	[-0.23, 0.02]	-4.26	> 0.999
Temperature	lnHgDw	-0.28	[-0.39, -0.15]	-0.37	< 0.001***
Max_Snow	NAOI	-0.03	[-0.16, 0.11]	-0.21	> 0.999
Max_Snow	HgDw	-0.01	[-0.14, 0.12]	-0.43	> 0.999
Max_Snow	HgWw	-0.03	[-0.16, 0.10]	-1.71	> 0.999
Max_Snow	∂^{13}C	-0.11	[-0.24, 0.02]	1.45	> 0.999
Max_Snow	∂^{15}N	0.10	[-0.03, 0.22]	-0.26	> 0.999
Max_Snow	lnHgDw	-0.02	[-0.15, 0.11]	-1.80	> 0.999
NAOI	HgDw	-0.12	[-0.25, 0.01]	-2.17	> 0.999
NAOI	HgWw	-0.14	[-0.27, -0.01]	0.56	0.627
NAOI	∂^{13}C	0.04	[-0.09, 0.17]	1.52	> 0.999
NAOI	∂^{15}N	-.10	[-0.03, 0.23]	-2.45	> 0.999
NAOI	lnHgDw	-0.16	[-0.29, -0.03]	44.37	0.315
HgDw	HgWw	0.95	[0.93, 0.96]	6.65	< 0.001***
HgDw	∂^{13}C	0.41	[0.29, 0.51]	0.26	< 0.001***
HgDw	∂^{15}N	0.02	[-0.11, 0.15]	33.61	> 0.999
HgDw	lnHgDw	0.91	[0.89, 0.93]	5.70	< 0.001***
HgWw	∂^{13}C	0.36	[0.24, 0.47]	0.82	< 0.001***
HgWw	∂^{15}N	0.06	[-0.08, 0.19]	26.89	> 0.999
HgWw	lnHgDw	0.87	[0.84, 0.90]	0.05	< 0.001***
∂^{13}C	∂^{15}N	0.00341	[-0.13, 0.13]	7.72	> 0.999
∂^{13}C	lnHgDw	0.46	[0.35, 0.56]	-0.55	< 0.001***
∂^{15}N	lnHgDw	-0.04	[-0.17, 0.09]		> 0.999

Annex 8: Correlation matrices using Pearson test for year, temperature, max snow depth (Max_Snow), North Atlantic Oscillation index (NAOI), mercury concentration dry weight (HgDw) (non- and *ln*-transformed), mercury concentration wet weight (HgWw), stable carbon isotope value ($\partial^{13}C$), and stable nitrogen isotope value ($\partial^{15}N$) for the first period (1986-2005).

Parameter 1	**Parameter 2**	**r**	**95% CI**	**t**	**p**
Year	Temperature	-0.06	[-0.22, 0.11]	-0.69	> 0.999
Year	Max_Snow	0.00501	[-0.16, 0.17]	0.06	> 0.999
Year	NAOI	-0.40	[-0.53, -0.25]	-5.12	< 0.001***
Year	HgDw	-0.11	[-0.27, 0.06]	-1.32	> 0.999
Year	HgWw	-0.16	[-0.32, 0.00]	-1.93	> 0.999
Year	$\partial^{13}C$	-0.28	[-0.43, -0.12]	-3.46	0.019*
Year	$\partial^{15}N$	-0.24	[-0.39, -0.08]	-2.96	0.086
Year	lnHgDw	-0.14	[-0.30, 0.02]	-1.70	> 0.999
Temperature	Max_Snow	-0.08	[-0.24, 0.09]	-0.90	> 0.999
Temperature	NAOI	0.35	[0.20, 0.49]	4.39	< 0.001***
Temperature	HgDw	-0.25	[-0.40, -0.09]	-3.09	0.061
Temperature	HgWw	-0.27	[-0.42, -0.11]	-3.33	0.029*
Temperature	$\partial^{13}C$	-0.01	[-0.18, 0.15]	-0.13	> 0.999
Temperature	$\partial^{15}N$	-0.17	[-0.33, -0.01]	-2.06	0.849
Temperature	lnHgDw	-0.28	[-0.43, -0.12]	-3.47	0.019
Max_Snow	NAOI	0.23	[0.07, 0.38]	2.76	0.149
Max_Snow	HgDw	-0.05	[-0.21, 0.12]	-0.56	> 0.999
Max_Snow	HgWw	-0.07	[-0.23, 0.10]	-0.79	> 0.999
Max_Snow	$\partial^{13}C$	-0.14	[-0.30, 0.03]	-1.63	> 0.999
Max_Snow	$\partial^{15}N$	0.21	[0.04, 0.36]	2.50	0.298
Max_Snow	lnHgDw	-0.12	[-0.28, 0.04]	-1.47	> 0.999
NAOI	HgDw	-0.02	[-0.18, 0.15]	-02.0	> 0.999
NAOI	HgWw	-0.04	[-0.21, 0.12]	-0.53	> 0.999
NAOI	$\partial^{13}C$	0.06	[-0.10, 0.23]	0.74	> 0.999
NAOI	$\partial^{15}N$	0.17	[0.01, 0.33]	2.07	0.849
NAOI	lnHgDw	-0.04	[-0.21, 0.12]	-0.49	> 0.999
HgDw	HgWw	0.94	[0.92, 0.96]	32.50	< 0.001***
HgDw	$\partial^{13}C$	0.36	[0.21, 0.50]	4.54	< 0.001***
HgDw	$\partial^{15}N$	-0.00384	[-0.17, 0.16]	-0.05	> 0.999
HgDw	lnHgDw	0.92	[0.88, 0.94]	26.92	< 0.001***
HgWw	$\partial^{13}C$	0.31	[0.15, 0.45]	3.83	0.006**
HgWw	$\partial^{15}N$	0.04	[-0.13, 0.20]	0.47	> 0.999
HgWw	lnHgDw	0.87	[0.82, 0.90]	20.66	< 0.001***
$\partial^{13}C$	$\partial^{15}N$	0.00056	[-0.16, 0.17]	0.00661	> 0.999
$\partial^{13}C$	lnHgDw	0.44	[0.29, 0.56]	5.70	< 0.001***
$\partial^{15}N$	lnHgDw	-0.05	[-0.22, 0.11]	-0.61	> 0.999

Annex 9: Correlation matrices using Pearson test for year, temperature, max snow depth (Max_Snow), North Atlantic Oscillation index (NAOI), mercury concentration dry weight (HgDw) (non- and *ln*-transformed), mercury concentration wet weight (HgWw), stable carbon isotope value (∂^{13}C), and stable nitrogen isotope value (∂^{15}N) for the second period (2006-2019).

Parameter 1	**Parameter 2**	**r**	**95% CI**	**t**	**p**
Year	Temperature	0.11	[-0.11, 0.32]	0.97	> 0.999
Year	Max_Snow	-0.11	[-0.32, 0.10]	-1.04	> 0.999
Year	NAOI	0.21	[0.00, 0.41]	1.96	> 0.999
Year	HgDw	0.04	[-0.18, 0.25]	0.36	> 0.999
Year	HgWw	0.09	[-0.13, 0.30]	0.84	> 0.999
Year	∂^{13}C	0.14	[-0.08, 0.34]	1.24	> 0.999
Year	∂^{15}N	0.47	[0.29, 0.62]	4.82	< 0.001***
Year	lnHgDw	-0.03	[-0.24, 0.19]	-0.27	> 0.999
Temperature	Max_Snow	-0.58	[-0.71, -0.42]	-6.48	< 0.001***
Temperature	NAOI	0.86	[0.79, 0.91]	15.07	< 0.001***
Temperature	HgDw	-0.35	[-0.52, -0.14]	-3.35	0.034*
Temperature	HgWw	-0.36	[-0.53, -0.15]	-3.43	0.028*
Temperature	∂^{13}C	0.17	[-0.05, 0.37]	1.52	> 0.999
Temperature	∂^{15}N	-0.02	[-0.23, 0.20]	-0.14	> 0.999
Temperature	lnHgDw	-0.36	[-0.53, -0.15]	-3.43	0.028*
Max_Snow	NAOI	)0.42	[-0.58, -0.22]	-4.14	0.003**
Max_Snow	HgDw	0.27	[0.06, 0.46]	2.52	0.316
Max_Snow	HgWw	0.23	[0.02, 0.43]	2.13	0.721
Max_Snow	∂^{13}C	0.07	[-0.15, 0.28]	0.60	> 0.999
Max_Snow	∂^{15}N	-0.11	[-0.32, 0.11]	-0.97	> 0.999
Max_Snow	lnHgDw	0.32	[0.11, 0.50]	3.05	0.081
NAOI	HgDw	-0.27	[-0.46, -0.06]	-2.57	0.290
NAOI	HgWw	-0.30	[-0.49, -0.09]	-2.87	0.130
NAOI	∂^{13}C	0.14	[-0.08, 0.35]	1.28	> 0.999
NAOI	∂^{15}N	0.03	[-0.19, 0.24]	0.27	> 0.999
NAOI	lnHgDw	-0.27	[-0.45, -0.05]	-2.48	0.338
HgDw	HgWw	0.96	[0.94, 0.98]	32.59	< 0.001***
HgDw	∂^{13}C	0.15	[-0.07, 0.36]	1.38	> 0.999
HgDw	∂^{15}N	0.01	[-0.21, 0.23]	0.09	> 0.999
HgDw	lnHgDw	0.95	[0.92, 0.97]	26.79	< 0.001***
HgWw	∂^{13}C	0.15	[-0.07, 0.35]	1.37	> 0.999
HgWw	∂^{15}N	0.05	[-0.16, 0.27]	0.48	> 0.999
HgWw	lnHgDw	0.91	[0.87, 0.94]	20.04	< 0.001***
∂^{13}C	∂^{15}N	-0.06	[-0.28, 0.15]	-0.57	> 0.999
∂^{13}C	lnHgDw	0.24	[0.02, 0.43]	2.19	0.662
∂^{15}N	lnHgDw	-0.07	[-0.28, 0.15]	-0.64	> 0.999

Annex 10: Tukey HSD test results for the mercury mean concentration per year.

Years	Difference	Confidence Intervals		p-value adjusted
		Lower	Upper	
1987-1986	0.295091882	-1.38268211	1.97286588	1.0000000
1989-1986	-1.393347372	-3.13000845	0.34331370	0.3629901
1990-1986	0.303827769	-2.15218188	2.75983741	1.0000000
1991-1986	-0.039123233	-1.59244012	1.51419365	1.0000000
1992-1986	-0.474258520	-2.02757541	1.07905837	0.9999992
1993-1986	-0.034078237	-1.61942565	1.55126917	1.0000000
1994-1986	0.059600852	-1.50803262	1.62723433	1.0000000
1995-1986	-0.422297003	-2.05963677	1.21504276	1.0000000
1996-1986	-0.057248144	-1.79390922	1.67941293	1.0000000
1997-1986	0.044976807	-1.56285892	1.65281254	1.0000000
1998-1986	-0.052346812	-1.66018254	1.55548892	1.0000000
1999-1986	-0.001091237	-1.58643865	1.58425617	1.0000000
2000-1986	-0.153030771	-1.70634766	1.40028612	1.0000000
2001-1986	-0.415313875	-2.02314960	1.19252185	1.0000000
2002-1986	0.275488481	-1.40228551	1.95326248	1.0000000
2003-1986	0.149440116	-1.40387677	1.70275700	1.0000000
2004-1986	-0.520252429	-1.99859651	0.95809165	0.9999812
2005-1986	-1.433382412	-3.11115641	0.24439158	0.2368649
2006-1986	-0.539351526	-2.36995303	1.29124998	0.9999997
2007-1986	-0.910125888	-2.58789988	0.76764811	0.9690870
2008-1986	-0.759949993	-2.43772399	0.91782400	0.9977342
2009-1986	-0.394235885	-2.07200988	1.28353811	1.0000000
2010-1986	-0.068995701	-1.80565678	1.66766537	1.0000000
2011-1986	-0.611865119	-2.16518201	0.94145177	0.9998150
2012-1986	-0.522371297	-2.10771871	1.06297611	0.9999955
2013-1986	-1.160357188	-3.16568067	0.84496629	0.9345648
2014-1986	-1.208589691	-2.77622316	0.35904378	0.4524235
2015-1986	-0.838533234	-2.66913474	0.99206827	0.9972765
2017-1986	-0.898808528	-2.45212541	0.65450836	0.9345650
2018-1986	-0.396791646	-1.95010853	1.15652524	1.0000000
2019-1986	-0.603488344	-2.17112182	0.96414513	0.9998818
1989-1987	-1.688439254	-3.03365114	-0.34322737	0.0012369
1990-1987	0.008735886	-2.18798592	2.20545769	1.0000000
1991-1987	-0.334215116	-1.43257602	0.76414579	0.9999993
1992-1987	-0.769350403	-1.86771131	0.32901050	0.6671803
1993-1987	-0.329170119	-1.47238039	0.81404016	0.9999998
1994-1987	-0.235491030	-1.35400703	0.88302497	1.0000000
1995-1987	-0.717388885	-1.93167255	0.49689478	0.9184743
1996-1987	-0.352340027	-1.69755191	0.99287186	1.0000000
1997-1987	-0.250115076	-1.42431227	0.92408212	1.0000000
1998-1987	-0.347438694	-1.52163589	0.82675850	0.9999996
1999-1987	-0.296183120	-1.43939339	0.84702715	1.0000000
2000-1987	-0.448122654	-1.54648356	0.65023825	0.9996398
2001-1987	-0.710405758	-1.88460295	0.46379144	0.8964997
2002-1987	-0.019603402	-1.28788133	1.24867453	1.0000000
2003-1987	-0.145651766	-1.24401267	0.95270914	1.0000000
2004-1987	-0.815344312	-1.80484143	0.17415281	0.3065930
2005-1987	-1.728474294	-2.99675222	-0.46019637	0.0001964
2006-1987	-0.834443409	-2.29892461	0.63003780	0.9447858

2007-1987	-1.205217771	-2.47349570	0.06306016	0.0897804
2008-1987	-1.055041875	-2.32331980	0.21323605	0.2874306
2009-1987	-0.689327768	-1.95760569	0.57895016	0.9683354
2010-1987	-0.364087584	-1.70929947	0.98112430	1.0000000
2011-1987	-0.906957002	-2.00531791	0.19140390	0.3022989
2012-1987	-0.817463179	-1.96067345	0.32574710	0.6232170
2013-1987	-1.455449070	-3.13322306	0.22232492	0.2101855
2014-1987	-1.503681573	-2.62219757	-0.38516558	0.0002720
2015-1987	-1.133625117	-2.59810632	0.33085609	0.4431997
2017-1987	-1.193900410	-2.29226131	-0.09553951	0.0159763
2018-1987	-0.691883528	-1.79024443	0.40647738	0.8496779
2019-1987	-0.898580227	-2.01709622	0.21993577	0.3601331
1990-1989	1.697175140	-0.54484467	3.93919495	0.4944795
1991-1989	1.354224138	0.16785877	2.54058951	0.0073063
1992-1989	0.919088852	-0.26727652	2.10545422	0.4413416
1993-1989	1.359269135	0.13126431	2.58727396	0.0120733
1994-1989	1.452948224	0.24789879	2.65799766	0.0027390
1995-1989	0.971050369	-0.32338037	2.26548111	0.5152682
1996-1989	1.336099227	-0.08187860	2.75407706	0.0981818
1997-1989	1.438324179	0.18142117	2.69522719	0.0070043
1998-1989	1.341000560	0.08409755	2.59790357	0.0210456
1999-1989	1.392256134	0.16425131	2.62026096	0.0081882
2000-1989	1.240316601	0.05395123	2.42668197	0.0280225
2001-1989	0.978033497	-0.27886951	2.23493650	0.4313040
2002-1989	1.668835852	0.32362397	3.01404774	0.0015689
2003-1989	1.542787488	0.35642212	2.72915286	0.0005805
2004-1989	0.873094942	-0.21326166	1.95945154	0.3592610
2005-1989	-0.040035040	-1.38524692	1.30517684	1.0000000
2006-1989	0.853995846	-0.67759526	2.38558695	0.9569237
2007-1989	0.483221484	-0.86199040	1.82843337	0.9999711
2008-1989	0.633397379	-0.71181451	1.97860926	0.9957724
2009-1989	0.999111487	-0.34610040	2.34432337	0.5381834
2010-1989	1.324351671	-0.09362616	2.74232950	0.1075210
2011-1989	0.781482252	-0.40488312	1.96784762	0.7829440
2012-1989	0.870976075	-0.35702875	2.09898090	0.6408029
2013-1989	0.232990184	-1.50367089	1.96965126	1.0000000
2014-1989	0.184757681	-1.02029176	1.38980712	1.0000000
2015-1989	0.554814137	-0.97677697	2.08640524	0.9999655
2017-1989	0.494538844	-0.69182652	1.68090421	0.9994648
2018-1989	0.996555726	-0.18980964	2.18292109	0.2683970
2019-1989	0.789859027	-0.41519041	1.99490846	0.7911270
1991-1990	-0.342951002	-2.44615201	1.76025001	1.0000000
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2003-2001	0.564753991	-0.42348021	1.55298819	0.9429285
2004-2001	-0.104938554	-0.97056821	0.76069110	1.0000000
2005-2001	-1.018068537	-2.19226573	0.15612866	0.2110710
2006-2001	-0.124037651	-1.50784232	1.25976702	1.0000000
2007-2001	-0.494812013	-1.66900921	0.67938518	0.9993484
2008-2001	-0.344636118	-1.51883331	0.82956108	0.9999997
2009-2001	0.021077990	-1.15311921	1.19527519	1.0000000
2010-2001	0.346318174	-0.91058483	1.60322118	0.9999999
2011-2001	-0.196551244	-1.18478544	0.79168296	1.0000000
2012-2001	-0.107057422	-1.14491092	0.93079608	1.0000000
2013-2001	-0.745043313	-2.35287904	0.86279242	0.9967186
2014-2001	-0.793275815	-1.80386386	0.21731223	0.4114978
2015-2001	-0.423219359	-1.80702403	0.96058531	0.9999992
2017-2001	-0.483494652	-1.47172885	0.50473955	0.9924179
2018-2001	0.018522229	-0.96971197	1.00675643	1.0000000
2019-2001	-0.188174469	-1.19876251	0.82241357	1.0000000
2003-2002	-0.126048365	-1.22440927	0.97231254	1.0000000
2004-2002	-0.795740910	-1.78523803	0.19375621	0.3579217
2005-2002	-1.708870892	-2.97714882	-0.44059297	0.0002579
2006-2002	-0.814840007	-2.27932121	0.64964120	0.9579883
2007-2002	-1.185614369	-2.45389230	0.08266356	0.1065308
2008-2002	-1.035438474	-2.30371640	0.23283945	0.3257386
2009-2002	-0.669724366	-1.93800229	0.59855356	0.9780447
2010-2002	-0.344484182	-1.68969607	1.00072770	1.0000000
2011-2002	-0.887353600	-1.98571450	0.21100730	0.3480108
2012-2002	-0.797859778	-1.94107005	0.34535050	0.6747001
2013-2002	-1.435845669	-3.11361966	0.24192833	0.2337788
2014-2002	-1.484078171	-2.60259417	-0.36556217	0.0003691
2015-2002	-1.114021715	-2.57850292	0.35045949	0.4832291

2017-2002	-1.174297008	-2.27265791	-0.07593610	0.0204190
2018-2002	-0.672280127	-1.77064103	0.42608078	0.8843022
2019-2002	-0.878976825	-1.99749282	0.23953917	0.4089816
2004-2003	-0.669692545	-1.42927949	0.08989440	0.1838812
2005-2003	-1.582822528	-2.68118343	-0.48446162	0.0000475
2006-2003	-0.688791642	-2.00885716	0.63127388	0.9812432
2007-2003	-1.059566004	-2.15792691	0.03879490	0.0761903
2008-2003	-0.909390109	-2.00775101	0.18897080	0.2968772
2009-2003	-0.543676001	-1.64203691	0.55468490	0.9910030
2010-2003	-0.218435817	-1.40480119	0.96792955	1.0000000
2011-2003	-0.761305235	-1.65811316	0.13550269	0.2485143
2012-2003	-0.671811413	-1.62301986	0.27939703	0.6498065
2013-2003	-1.309797304	-2.86311419	0.24351958	0.2610919
2014-2003	-1.358029807	-2.27941236	-0.43664725	0.0000257
2015-2003	-0.987973350	-2.30803887	0.33209217	0.5206278
2017-2003	-1.048248644	-1.94505657	-0.15144072	0.0048454
2018-2003	-0.546231762	-1.44303968	0.35057616	0.8895736
2019-2003	-0.752928460	-1.67431101	0.16845409	0.3237923
2005-2004	-0.913129982	-1.90262710	0.07636714	0.1212068
2006-2004	-0.019099097	-1.25006654	1.21186835	1.0000000
2007-2004	-0.389873459	-1.37937058	0.59962366	0.9998141
2008-2004	-0.239697564	-1.22919468	0.74979956	1.0000000
2009-2004	0.126016544	-0.86348057	1.11551366	1.0000000
2010-2004	0.451256728	-0.63509987	1.53761333	0.9994981
2011-2004	-0.091612690	-0.85119963	0.66797425	1.0000000
2012-2004	-0.002118868	-0.82522602	0.82098828	1.0000000
2013-2004	-0.640104758	-2.11844884	0.83823932	0.9989463
2014-2004	-0.688337261	-1.47678744	0.10011292	0.1996038
2015-2004	-0.318280805	-1.54924825	0.91268664	1.0000000
2017-2004	-0.378556098	-1.13814304	0.38103084	0.9900715
2018-2004	0.123460783	-0.63612616	0.88304773	1.0000000
2019-2004	-0.083235915	-0.87168609	0.70521426	1.0000000
2006-2005	0.894030886	-0.57045032	2.35851209	0.8871402
2007-2005	0.523256524	-0.74502140	1.79153445	0.9995570
2008-2005	0.673432419	-0.59484551	1.94171035	0.9764147
2009-2005	1.039146527	-0.22913140	2.30742445	0.3182824
2010-2005	1.364386711	0.01917483	2.70959859	0.0418814
2011-2005	0.821517292	-0.27684361	1.91987820	0.5220980
2012-2005	0.911011115	-0.23219916	2.05422139	0.3778636
2013-2005	0.273025224	-1.40474877	1.95079922	1.0000000
2014-2005	0.224792721	-0.89372328	1.34330872	1.0000000
2015-2005	0.594849177	-0.86963203	2.05933038	0.9996684
2017-2005	0.534573884	-0.56378702	1.63293479	0.9929847
2018-2005	1.036590766	-0.06177014	2.13495167	0.0965587
2019-2005	0.829894067	-0.28862193	1.94841006	0.5405143
2007-2006	-0.370774362	-1.83525557	1.09370684	1.0000000
2008-2006	-0.220598467	-1.68507967	1.24388274	1.0000000
2009-2006	0.145115641	-1.31936556	1.60959685	1.0000000
2010-2006	0.470355825	-1.06123528	2.00194693	0.9999991
2011-2006	-0.072513593	-1.39257911	1.24755193	1.0000000
2012-2006	0.016980229	-1.34063018	1.37459064	1.0000000
2013-2006	-0.621005662	-2.45160717	1.20959584	0.9999915
2014-2006	-0.669238164	-2.00612048	0.66764415	0.9894167
2015-2006	-0.299181708	-1.93652147	1.33815806	1.0000000

2017-2006	-0.359457001	-1.67952252	0.96060852	1.0000000
2018-2006	0.142559880	-1.17750564	1.46262540	1.0000000
2019-2006	-0.064136818	-1.40101914	1.27274550	1.0000000
2008-2007	0.150175895	-1.11810203	1.41845382	1.0000000
2009-2007	0.515890003	-0.75238792	1.78416793	0.9996595
2010-2007	0.841130187	-0.50408170	2.18634207	0.8592104
2011-2007	0.298260769	-0.80010014	1.39662167	1.0000000
2012-2007	0.387754591	-0.75545568	1.53096487	0.9999915
2013-2007	-0.250231300	-1.92800529	1.42754269	1.0000000
2014-2007	-0.298463802	-1.41697980	0.82005219	1.0000000
2015-2007	0.071592654	-1.39288855	1.53607386	1.0000000
2017-2007	0.011317361	-1.08704354	1.10967826	1.0000000
2018-2007	0.513334242	-0.58502666	1.61169515	0.9962397
2019-2007	0.306637544	-0.81187845	1.42515354	0.9999999
2009-2008	0.365714108	-0.90256382	1.63399204	0.9999998
2010-2008	0.690954292	-0.65425759	2.03616618	0.9848338
2011-2008	0.148084874	-0.95027603	1.24644578	1.0000000
2012-2008	0.237578696	-0.90563158	1.38078897	1.0000000
2013-2008	-0.400407195	-2.07818119	1.27736680	1.0000000
2014-2008	-0.448639698	-1.56715569	0.66987630	0.9997385
2015-2008	-0.078583241	-1.54306445	1.38589796	1.0000000
2017-2008	-0.138858535	-1.23721944	0.95950237	1.0000000
2018-2008	0.363158347	-0.73520256	1.46151925	0.9999952
2019-2008	0.156461649	-0.96205435	1.27497764	1.0000000
2010-2009	0.325240184	-1.01997170	1.67045207	1.0000000
2011-2009	-0.217629234	-1.31599014	0.88073167	1.0000000
2012-2009	-0.128135412	-1.27134569	1.01507486	1.0000000
2013-2009	-0.766121303	-2.44389530	0.91165269	0.9974123
2014-2009	-0.814353805	-1.93286980	0.30416219	0.5833473
2015-2009	-0.444297349	-1.90877855	1.02018386	0.9999993
2017-2009	-0.504572642	-1.60293355	0.59378826	0.9971460
2018-2009	-0.002555761	-1.10091667	1.09580514	1.0000000
2019-2009	-0.209252459	-1.32776846	0.90926354	1.0000000
2011-2010	-0.542869418	-1.72923479	0.64349595	0.9973220
2012-2010	-0.453375596	-1.68138042	0.77462923	0.9999490
2013-2010	-1.091361487	-2.82802256	0.64529959	0.8527915
2014-2010	-1.139593989	-2.34464343	0.06545545	0.0945188
2015-2010	-0.769537533	-2.30112864	0.76205357	0.9888467
2017-2010	-0.829812826	-2.01617820	0.35655254	0.6701300
2018-2010	-0.327795945	-1.51416131	0.85856942	0.9999999
2019-2010	-0.534492643	-1.73954208	0.67055679	0.9984052
2012-2011	0.089493822	-0.86171462	1.04070227	1.0000000
2013-2011	-0.548492069	-2.10180896	1.00482482	0.9999798
2014-2011	-0.596724571	-1.51810712	0.32465798	0.8101169
2015-2011	-0.226668115	-1.54673363	1.09339740	1.0000000
2017-2011	-0.286943408	-1.18375133	0.60986451	0.9999977
2018-2011	0.215073473	-0.68173445	1.11188140	1.0000000
2019-2011	0.008376775	-0.91300578	0.92975933	1.0000000
2013-2012	-0.637985891	-2.22333330	0.94736152	0.9997216
2014-2012	-0.686218394	-1.66063045	0.28819367	0.6559011
2015-2012	-0.316161938	-1.67377235	1.04144848	1.0000000
2017-2012	-0.376437231	-1.32764568	0.57477121	0.9997977
2018-2012	0.125579651	-0.82562879	1.07678810	1.0000000
2019-2012	-0.081117047	-1.05552911	0.89329501	1.0000000

2014-2013	-0.048232503	-1.61586598	1.51940097	1.0000000
2015-2013	0.321823953	-1.50877755	2.15242546	1.0000000
2017-2013	0.261548660	-1.29176823	1.81486555	1.0000000
2018-2013	0.763565542	-0.78975135	2.31688243	0.9918698
2019-2013	0.556868844	-1.01076463	2.12450232	0.9999771
2015-2014	0.370056456	-0.96682586	1.70693877	0.9999999
2017-2014	0.309781163	-0.61160139	1.23116372	0.9999930
2018-2014	0.811798045	-0.10958451	1.73318060	0.1849241
2019-2014	0.605101346	-0.34021721	1.55041990	0.8275558
2017-2015	-0.060275293	-1.38034081	1.25979023	1.0000000
2018-2015	0.441741588	-0.87832393	1.76180711	0.9999937
2019-2015	0.235044890	-1.10183743	1.57192721	1.0000000
2018-2017	0.502016882	-0.39479104	1.39882480	0.9549006
2019-2017	0.295320183	-0.62606237	1.21670274	0.9999976
2019-2018	-0.206696698	-1.12807925	0.71468585	1.0000000

Annex 11: *A posteriori* Tukey HSD pairwise comparisons of the mercury concentrations (*dw*; HgDw) among years from the different study periods.

Reference Year	**p-value < 0.01**	**p-value < 0.001**	**p-value < 0.0001**
1986			
1987	1989	2005; 2014	
1989	1987; 1991; 1994; 1997; 1999; 2002	2003	
1990			
1991	1989	2005; 2014	
1992			
1993	2005; 2014		
1994	1989	2005; 2014	
1995			
1996			
1997	1989; 2005; 2014		
1998	2005; 2014		
1999	1989; 2005; 2014		
2000	2005; 2014		
2001			
2002	1989	2005; 2014	
2003	2017	1989	2005; 2014
2004			
2005	1993; 1997; 1998; 1999; 2000	1987; 1991; 1994; 2002	2003
2006			
2007			
2008			
2008			
2009			
2010			
2011			
2012			
2013			
2014	1993; 1997; 1998; 1999; 2000	1987; 1991; 1994; 2002	2003
2015			
2017	2003		
2018			
2019			

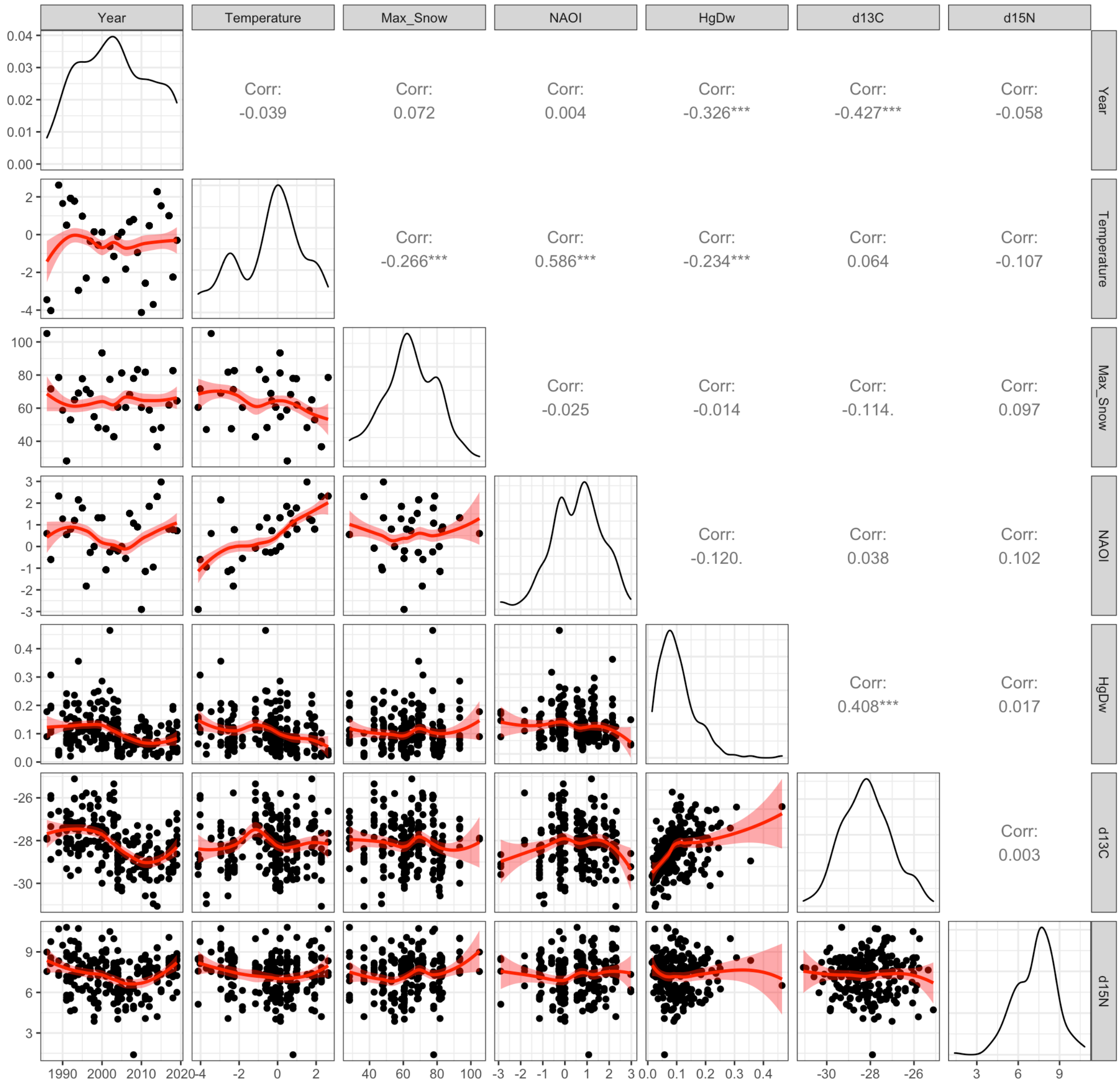
Annex 12: Selection among eighteen different generalized additive models explaining the annual variation of the *ln*-transformed Hg concentrations (*dw*) in tawny owl eggs between 1986 and 2005. Y: Year; T: Temperature (°C); MS: Max Snow depth (cm); NAOI: North Atlantic Oscillation Index; $\partial^{13}C$: stable carbon isotope value; $\partial^{15}N$: stable nitrogen isotope value; *GCV*: generalized cross-validation; *AICc*: Akaike's Information Criterion corrected for sample size; *AICcWt*: *AICc* weight; *Cum.Wt*: Cumulated weight.

log(HgDw) ~ Models	GCV	R.sq adj.	Explained deviance	AICc	ΔAICc	AICcWt	Cum.Wt
Y + T * $\partial^{13}C$	0.286	0.331	0.218	220.64	0	0.31	0.55
Y + T + $\partial^{13}C$	0.288	0.312	0.217	222.65	2.00	0.24	0.24
Y + NAOI * $\partial^{13}C$	0.322	0.263	0.151	236.25	15.60	0.00	0.00
Y + MS + $\partial^{13}C$	0.327	0.222	0.150	240.31	19.66	0.00	0.00
Y + MS * $\partial^{13}C$	0.331	0.230	0.197	240.87	20.22	0.00	0.00
Y + NAOI + $\partial^{13}C$	0.329	0.220	0.147	241.01	20.37	0.00	0.00
Y + $\partial^{13}C$	0.327	0.210	0.060	241.21	20.56	0.00	0.00
Y + T + $\partial^{15}N$	0.337	0.197	0.151	244.68	24.03	0.00	0.00
Y + T	0.336	0.189	0.146	245.02	24.37	0.00	0.00
Y + T * $\partial^{15}N$	0.341	0.198	0.325	245.68	25.03	0.00	0.00
Y + MS	0.360	0.133	0.105	254.61	33.96	0.00	0.00
Y + MS + $\partial^{15}N$	0.365	0.133	0.107	255.82	35.17	0.00	0.00
Y + NAOI	0.366	0.126	0.071	256.50	35.85	0.00	0.00
Y + NAOI * $\partial^{15}N$	0.374	0.135	0.319	257.85	37.21	0.00	0.00
Y + MS * $\partial^{15}N$	0.372	0.127	0.208	257.89	37.24	0.00	0.00
Y + NAOI + $\partial^{15}N$	0.372	0.123	0.078	257.97	37.33	0.00	0.00
Y	0.369	0.099	0.123	258.81	38.16	0.00	0.00
Y + $\partial^{15}N$	0.371	0.105	0.127	258.95	38.30	0.00	0.00

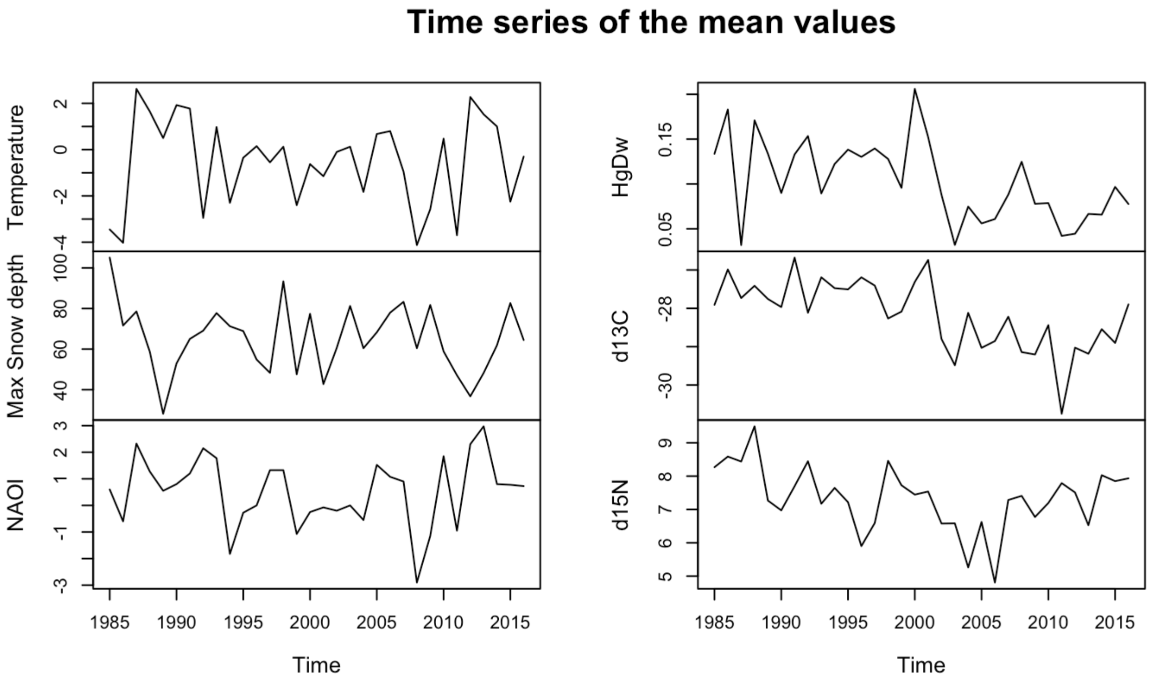
Annex 13: Selection among eighteen different generalized additive models explaining the annual variation of the *ln*-transformed Hg concentrations (*dw*) in tawny owl eggs between 2006 and 2019. Y: Year; T: Temperature (°C); MS: Max Snow depth (cm); NAOI: North Atlantic Oscillation Index; ∂^{13}C: stable carbon isotope value; ∂^{15}N: stable nitrogen isotope value; *GCV*: generalized cross-validation; *AICc*: Akaike's Information Criterion corrected for sample size; *AICcWt*: *AICc* weight; *Cum.Wt*: Cumulated weight.

log(HgDw) ~ Models	GCV	R.sq adj.	Explained deviance	AICc	ΔAICc	AICcWt	Cum.Wt
Y + T + ∂^{13}C	0.299	0.188	0.217	134.54	0	0.12	0.61
Y + T * ∂^{15}N	0.318	0.246	0.325	136.02	1.47	0.03	0.49
Y + T * ∂^{13}C	0.310	0.177	0.218	136.84	2.29	0.01	0.46
Y + NAOI * ∂^{15}N	0.333	0.230	0.319	139.14	4.60	0.01	0.45
Y + T	0.320	0.119	0.146	140.58	6.04	0.16	0.44
Y + MS * ∂^{13}C	0.326	0.149	0.197	140.59	6.05	0.00	0.28
Y + MS + ∂^{13}C	0.324	0.118	0.150	141.39	6.85	0.05	0.28
Y + NAOI + ∂^{13}C	0.326	0.114	0.147	141.71	7.16	0.05	0.23
Y + MS * ∂^{15}N	0.333	0.150	0.208	141.77	7.23	0.00	0.18
Y + T + ∂^{15}N	0.329	0.114	0.151	142.24	7.70	0.04	0.18
Y + MS	0.330	0.082	0.105	143.53	8.98	0.04	0.14
Y + NAOI * ∂^{13}C	0.336	0.108	0.151	143.58	9.03	0.00	0.10
Y	0.333	0.091	0.123	143.59	9.05	0.06	0.10
Y + ∂^{15}N	0.343	0.085	0.127	145.47	10.92	0.02	0.04
Y + MS + ∂^{15}N	0.341	0.072	0.107	145.62	11.08	0.01	0.2
Y + NAOI	0.342	0.048	0.071	146.49	11.94	0.01	0.01
Y + ∂^{13}C	0.346	0.036	0.060	147.49	12.95	0.00	0.01
Y + NAOI + ∂^{15}N	0.352	0.043	0.078	148.09	13.55	0.00	0.00

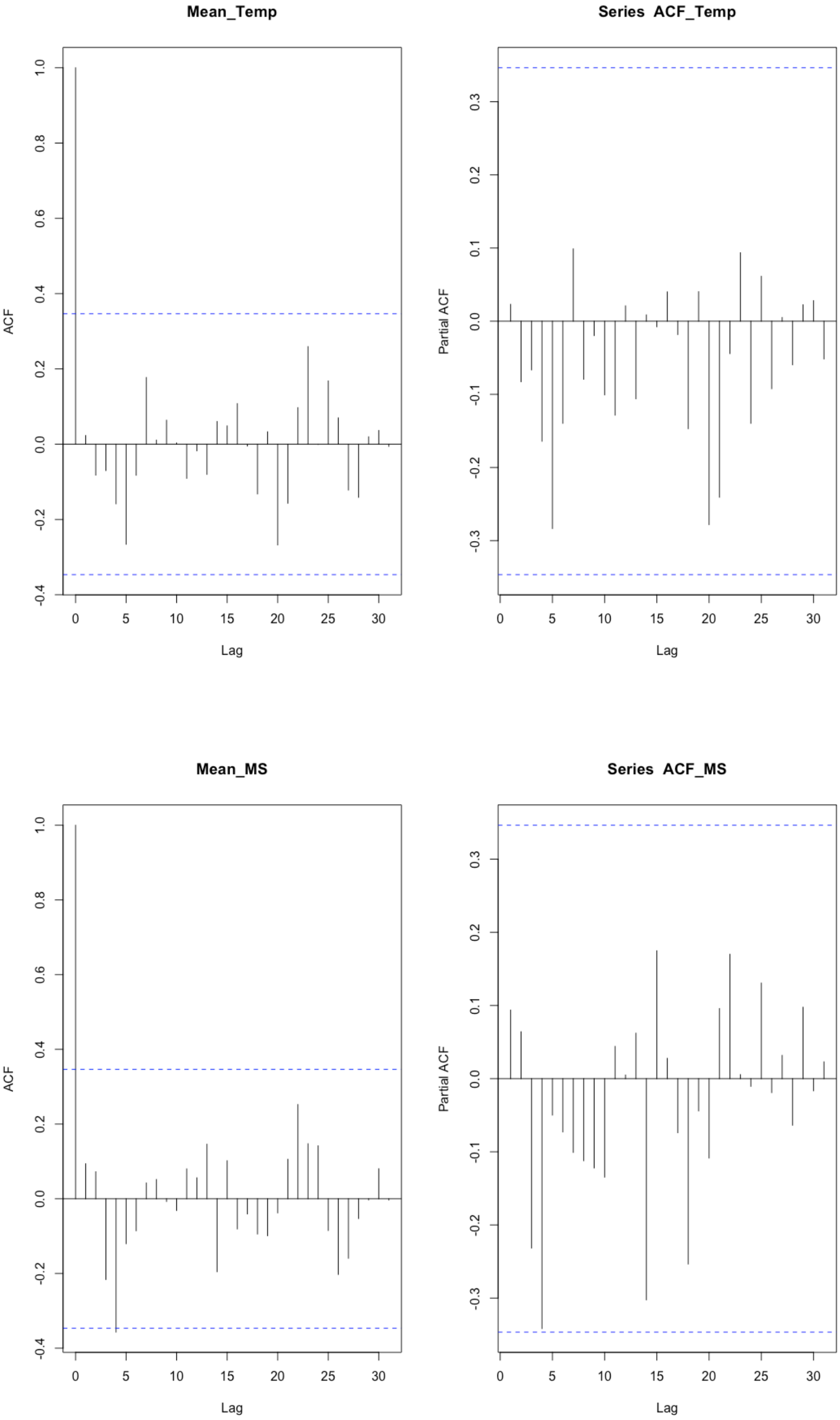
Annex 14 : Scatterplot with loess regression.

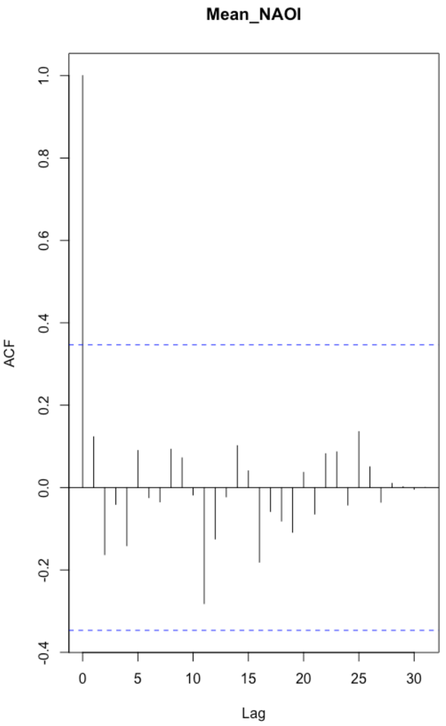


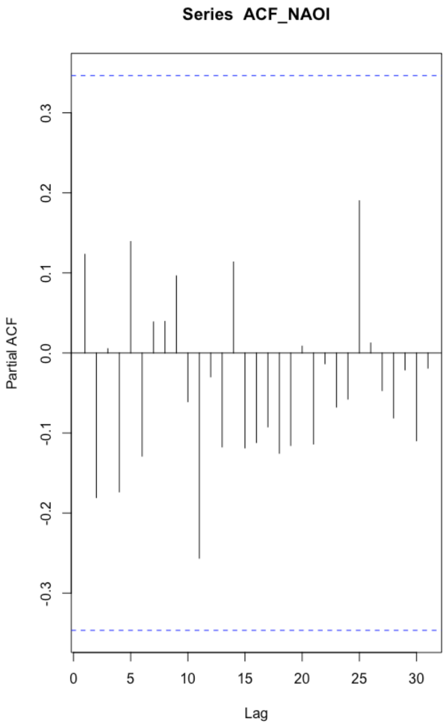
Annex 15: Time series plots.

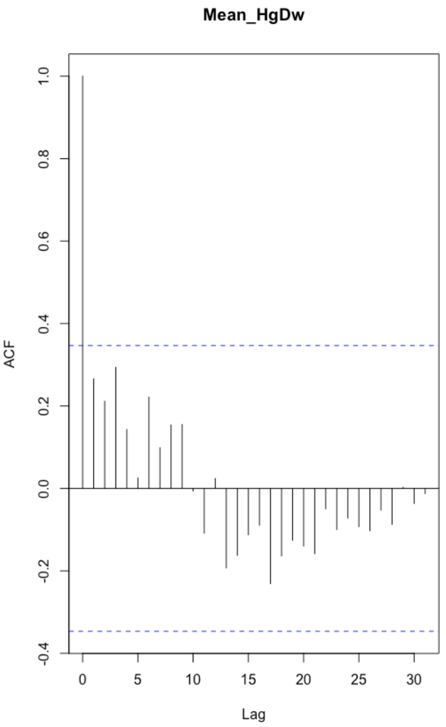


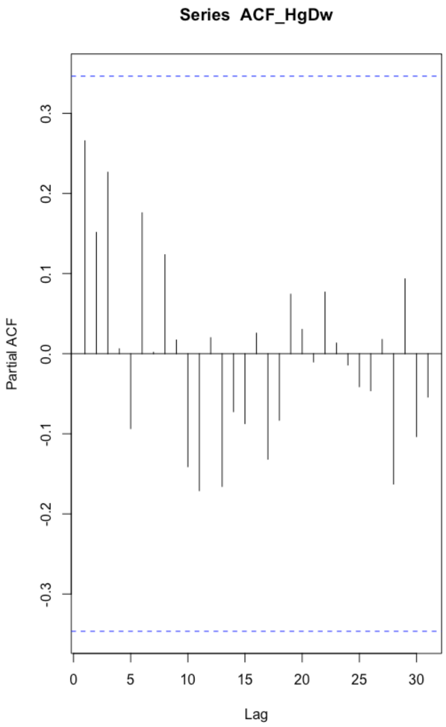
Annex 16: ACF and PACF plots for temperature (Temp), max snow depth (MS), North Atlantic Oscillation index (NAOI), mercury concentrations dry weight (HgDw), stable carbon isotope value ($\partial^{13}C$), and stable nitrogen isotope value ($\partial^{15}N$).

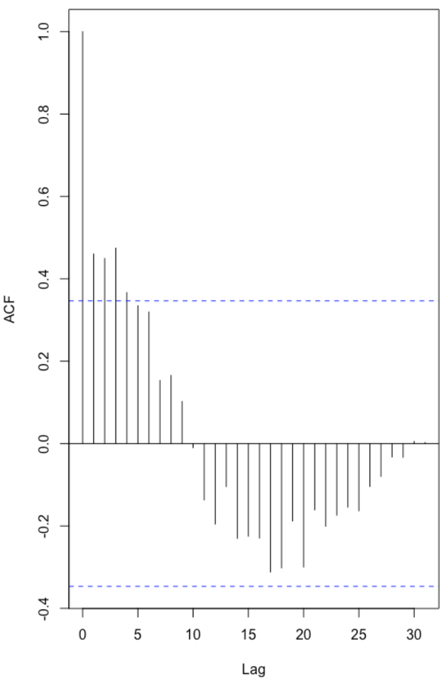


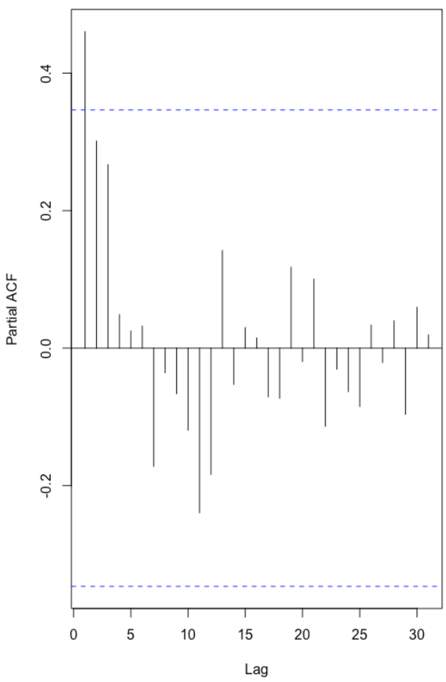

Mean_NAOI
ACF
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
25
30
Lag

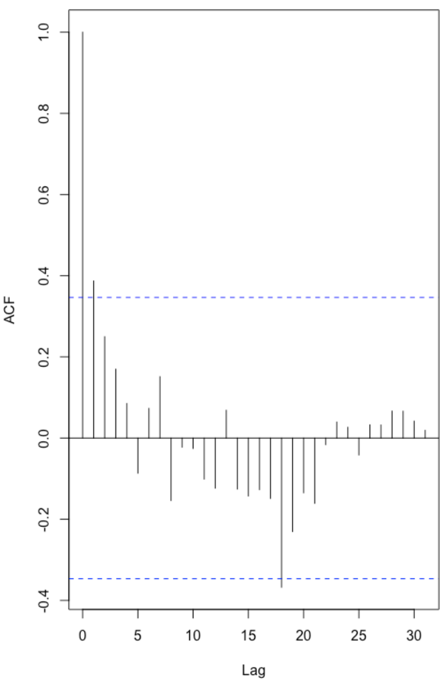

Series ACF_NAOI
Partial ACF
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
5
10
15
20
25
30
Lag

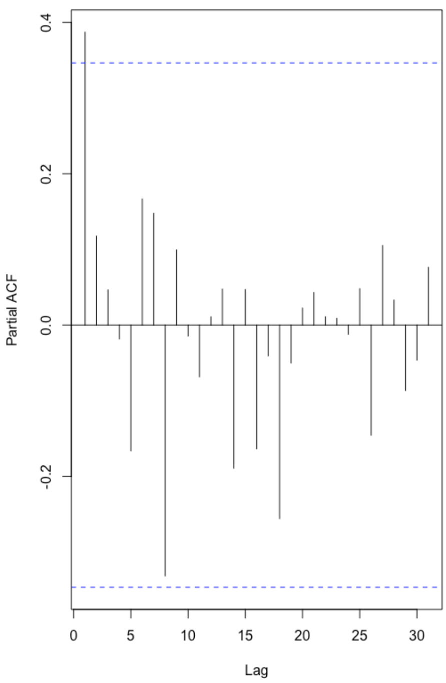

Mean_HgDw
ACF
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
25
30
Lag


Series ACF_HgDw
Partial ACF
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
5
10
15
20
25
30
Lag

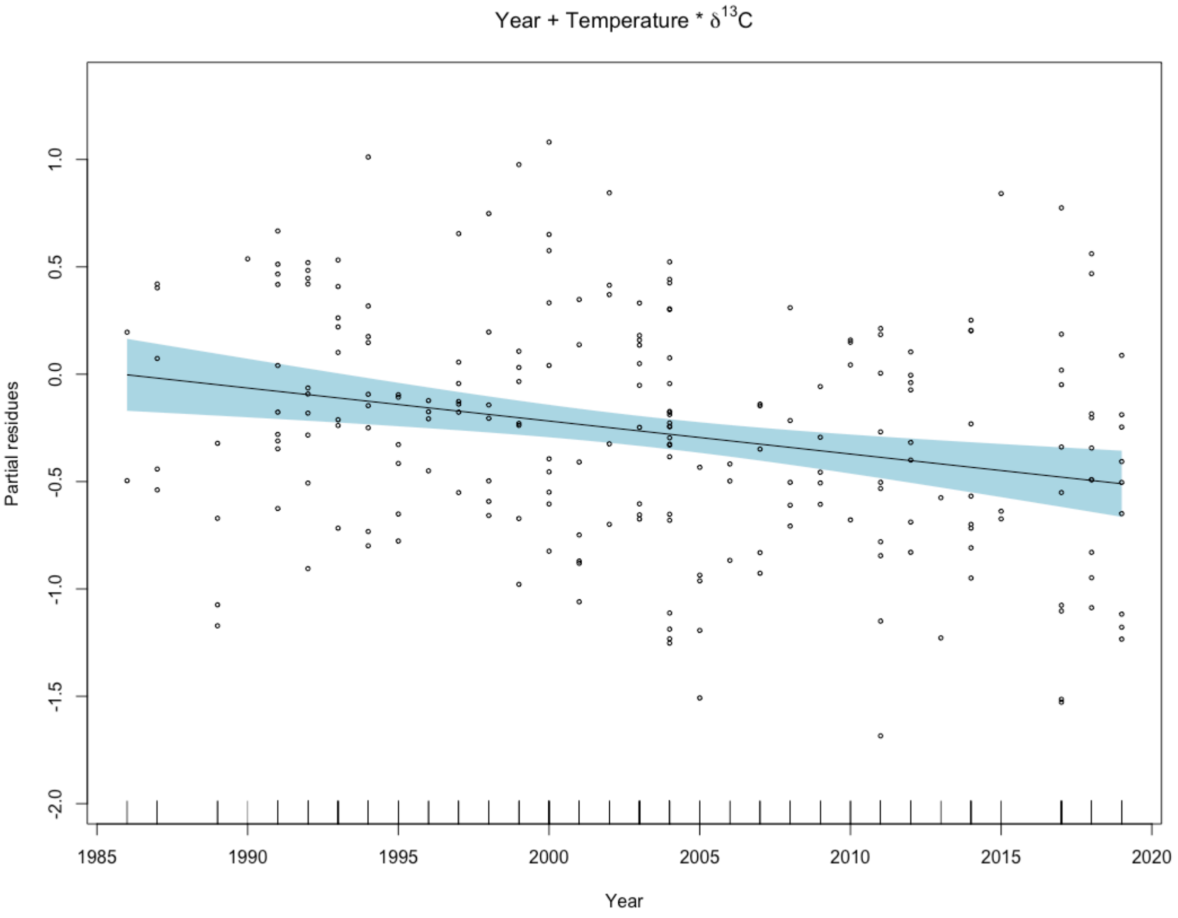

Mean_d13C


Series ACF_d13C

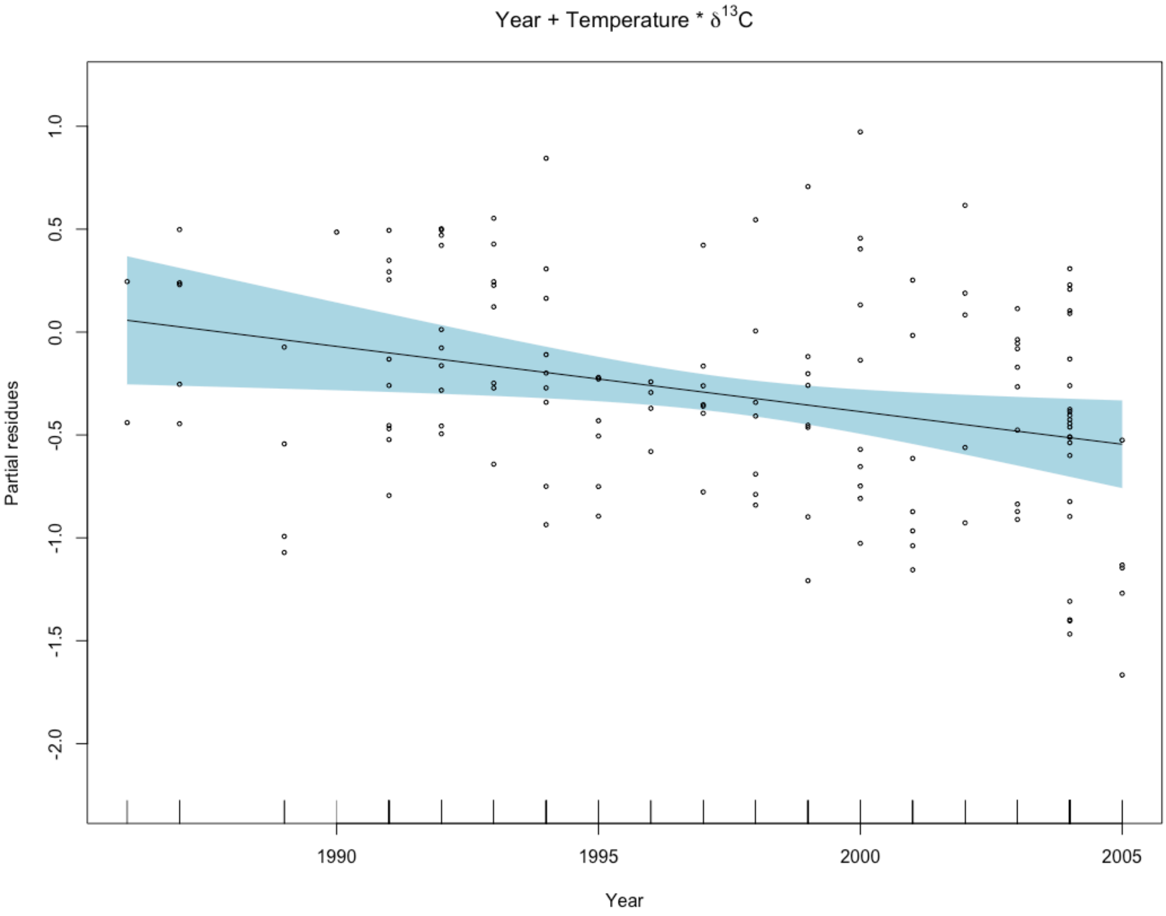

Mean_d15N


Series ACF_d15N

Annex 17: Best model found for the entire period (1986-2019).



Annex 18: Best model found for the first period (1986-2005).



Annex 19: Second-best model found for the second period (2006-2019).