Long-term Management Plan

for the

European mink

(*Mustela lutreola*)

European Endangered Species Programme (EEP)

EEP coordinator

Tiit Maran, Tallinn Zoo

Population Biologists

Elmar Fienieg and Kristine Schad, EAZA Executive Office

8 November 2017

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EEP Executive Summary

European mink (*Mustela lutreola*)

In the past, the Western and Eastern in situ population of European mink were thought to be different subspecies. Currently however, based on historical distribution and molecular genetic data, the European mink is thought to be a panmictic species (Youngman 1982; Cabria et al. 2015).
The current EEP population is descended from Russian (Eastern) founders. The only other European mink ex situ population is managed by the Spanish Environmental Ministry and technically assisted by external assistance. This population is descended from Spanish (Western) founders. In isolation, there is a high risk of losing this Western population due to its small size and low genetic diversity. Merging this population with the EEP population would significantly increase the viability of the Western ex situ population and to a lesser extent that of the current EEP population. **Therefore, the aim of the EEP is to incorporate the Spanish breeding programme (Western ex situ population). Whether this will happen, is a political decision that still needs to be made in the future. This plan was nonetheless written under the assumption that this will happen at a certain moment in the coming years**.
As of 30 April 2017, the ex situ population of the Critically Endangered European mink population consists of 267 individuals, of which 140 are males and 127 are females, held at 26 institutions. Breeding of European mink mainly takes place in specialised breeding centres.

The future roles of the European mink EEP are to:

- Maintain a genetically diverse, demographically healthy and behaviourally competent population as a back-up in case all wild populations of European mink go extinct.
- Encourage, support and endorse efforts aimed to restore or establish viable wild populations of European mink in Europe that are in accordance with the IUCN Translocation Guidelines (IUCN SSC 2013).
- Further integrate *in situ* and *ex situ* conservation activities to the benefit of both.
- Be a flagship species and provide conservation education messages for the ecologically important small stream and river ecosystems in Europe.
- Educate zoo visitors about the plight of the European mink and the damage of invasive species in general and the American mink in particular.
- Support conservation research on the European mink and encourage public and research institutions to become involved in this. By collecting biomaterials, the EEP also aims to facilitate research in the future.
- Lobby the EU and increase the awareness of other decision makers to produce legislation and policies that favour the conservation status of the European mink.

Conclusions for the EEP Population:

- The Western and Eastern ex situ populations will eventually be managed as one combined population under the umbrella of the EEP. It will take several years before breeding between the two populations is expected to happen on a large scale. Also, if any additional breeding centres are initiated for European mink, the EEP aims to integrate these in the EEP as well.
- The ex situ European mink population is demographically reasonably stable and planned to grow slightly in the coming years to a population size of 330 individuals based on available institutional space. The large proportion of males that are not able to breed due to aggressive or passive behaviour poses a demographic risk. Therefore, the EEP will investigate why these males are exhibiting these unusual behaviours.

- There are currently only five institutions that can breed a significant number of European mink. The uncertainty of future funds for some of these institutions poses a risk for the ability of the EEP to maintain the current population size. Therefore, a larger number of institutions that can contribute to breeding, which requires keeping at least 10 European mink, are necessary for the EEP's long-term stability.
- The Western ex situ population has very low genetic diversity, following Cabria et al. (2015). Exchange with the Eastern ex situ population is therefore important on the short-term to avoid inbreeding depression. The Eastern ex situ population is currently still genetically healthy. However, due to the short generation time of the European mink, genetic diversity is lost rapidly from the population. In order to reach its genetic goal to maintain a population with a potential genetic diversity of 97.5% for as long as possible, the EEP will work on:
    - Breeding the EEP population by mean kinship
    - Obtaining new founders from any wild population, in particular the genetically diverse Romanian wild population
    - Cryopreservation of sperm so that genetic diversity that is lost from the population can be returned to the population in the future.
- To facilitate research in the future, the EEP will support biobanking on a large scale, once funds have been found for this.
- Sub-populations of European mink will be organised to decrease costs and travel-time for European mink transfers.
- The EEP will continue to increase awareness about the European mink to governmental decision makers and the general public, as this is deemed to be essential for improving the situation of the European mink wild populations as well as for maintaining the EEP population in the long-term.
- This population will be re-evaluated annually by the European mink EEP Coordinator and Species Committee.
- Once the EEP has been able to organise this, institutional breeding recommendations will be developed by the EEP Coordinator together with the Coordinator of the relevant sub-population and provided by the Coordinator of the relevant sub-population.

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Acknowledgements

Thank you to everyone that attended the European mink EEP long-term management planning meeting on 11 and 12 May 2017 in Ploiesti, Romania. Also, thank you to Kristel Nemvalts (TALLIN) for preparing the studbook data and to Dana Canari (Romanian Zoo and Aquaria Federation) and Aude Desmoulins (LE VIGEN) for their work for the organisation of the meeting.

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Meeting Attendees:
Tiit Maran, EEP Coordinator (Tallinn zoo)
Aude Haelewyn (Small Carnivore TAG Chair)
Julien Steinmetz (Office National de la Chasse et de la Faune Sauvage (ONCFS), French Conservation Plan for European Mink)
Maylis Fayet (Office National de la Chasse et de la Faune Sauvage (ONCFS), French Conservation Plan for European Mink)
Asun Gómez (coordination of in situ conservation in Spain, Tragsatec)
Silvia Villaverde (veterinary in the private breeding centre, FIEB Foundation in Spain)
Madis Põdra (coordination of ex situ conservation, European mink Association in Spain)
Paul Marinari (Black-footed ferret SSP Coordinator in United States)
Mike Lockhart (Black-footed ferret project in United States)
Kristine Schad, Population biologist (EAZA Executive office)
Katharina Herrmann Executive coordinator (EAZA Executive office)
Elmar Fienieg, Population biologist (EAZA Executive office)

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European mink EEP Species Committee*[1]

*[1] The Species Committee will be restructured in the near future, after discussions with current non-EAZA members have progressed and when more is clear on EAZA's new breeding programme structure.

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Katharina Herrmann	katharina.herrmann@eaza.net	EAZA Executive office	EAZA Executive Office TAG Liaison
Elmar Fienieg	elmar.fienieg@eaza.net		Population Biology Advisor
Main contact for research on cryopreservation is to be determined. Until a candidate has been found, please send questions/comments on this to Tiit Maran (Tiit.maran@tallinnzoo.ee) or Madis Põdra (madis.podra@yahoo.es).			Central contact for research on cryopreservation

Institutions involved in preparation of the Long-term Management Plan

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Suggested Actions

Actions for EEP Coordinator and Species Committee

- Elect a new Species Committee once the Spanish breeding centres have become formal non-EAZA EEP participants.

- Continue contact with Daniel Nuijten (EAZA EU Policy Manager) to lobby at the European Union.
    - Communicate that a European Commission member is needed to champion the European mink.
    - Continue efforts to add the American mink to the EU Invasive Alien Species list.
    - Take the next steps towards developing a European Action Plan for the European mink.

- Once the Romanian European mink working group is established, work with them to develop a Romanian Action Plan for European mink to share with the Romanian government
- Once the Romanian European mink working group is established, provide competence and help to lobby for the development of an ex situ breeding centre in Romania.

- Move forward with the different molecular genetic studies that are planned
    - Determine if the introduced Hiiumaa population is in need of genetic supplementation in the coming years.
    - Study the genetic diversity of the founders originating from the Western population and the Eastern wild population to determine if this follows the same pattern found in earlier studies (Cabria et al. 2015).
    - Contact the Smithsonian's National Zoo and conservation biology institute, Washington DC, USA and the Earlham Institute, Norwich, UK about their work on mustelid genomics to determine if they are also interested in genome sequencing of the European mink, and if so, determine how this can best fit in with the different molecular genetic studies that are necessary.

- Contact the Steinhuder Meer Conservation station, Germany, to determine whether they will continue with reintroductions in the future and how they will fit in with the EEP.
- For reintroductions or translocations on Saaremaa, find funding and a suitable person that lives on Saaremaa to help with this.
- Continue contact and try to promote contact with Dr. Skumatov and associates with the aim to get a better idea on the status of Kunashir island.

- Communicate to all involved to find a volunteer to create a yearly newsletter for European mink, reporting about the progress made with in situ and ex situ efforts.
- Continue to organise European Mink Day (23 April) with schools, zoos and aquaria. For this, the EEP aims to have a much wider involvement (Action Kristel Nemvalts and anyone that wants to be involved)

- Determine which non-EAZA institutions will become part of the EEP as formal non-EAZA participant and which ones will not (e.g. because they will only take on surplus). This involves the following non-EAZA EEP institutions: ADEFFA (Associació de defensa i estudi de la fauna i flora autòctona), ALAVA (Private person), CORDOBA (Municipal Park Zoo), FIEB (FIEB foundation), HANKENSB (Otter-Zentrum Hankensbüttel), PARQNATUR (Parque de la Naturaleza de Navarra), PONTSUERT (Centro de Fauna del Pont de Suert).

- Look for more EAZA institutions that want to participate in the EEP and have at least 10 enclosures available at their institution.
- When needed, contact Elmar Fienieg and Kristine Schad about creating tailor-made MateRx matrices to facilitate assigning breeding pairs or to discuss management strategies when obtaining individuals of wild populations descending from the EEP population.
- Continue to disseminate information on European mink to all EEP participants and other partners.

Actions for current institutional holders of European mink

- Once the necessary protocols and biobanking locations are developed and it is clear how and where samples will be stored, obtain bio-samples from individuals for cryopreservation.
- Educate visitors about the plight of the European mink, the damage of invasive species such as the American mink and the ecological importance of small stream and river ecosystems.
- Share your environment enrichment experience, behavioural data and experience with educational activities with the EEP Coordinator.
- Collaborate, when the need arises, with studies on males with aggressive/passive behavioural issues.
- Communicate to the EEP Coordinator if you would like to help the EEP by performing a qualitative behavioural/physiological study (including on Artificial insemination) on European mink at your institution.

Actions for the TAG chair

- Assign an Educational Advisor that can provide educational materials for European mink, encourage zoos to work with these materials and directly educate relevant politicians.
- Investigate the nutritional needs of European mink, particularly regarding the effect of diet on weight.
  - Ask Francis Cabana, as the TAG Nutrition Advisor, to consider looking into this, possibly with the help of a student.

Action for Office National de la Chasse et de la Faune Sauvage (ONCFS), France

- Contact Emmanuel Mouton Calviac Zoo (CALVIAC) and a member of the French Association of Zoos (AFdPZ), to help put the European mink on AFdPZ’s agenda.
- Help in identifying institutions that are interested to join the EEP.
- Evaluate the possibilities for French research institute or universities to take part to the studies listed in the EEP long term management plan.

Actions for the (to be established) Romanian European mink working group

- Continue to contact the relevant people in Romania to establish a Romanian European mink working group (Action Dana Canari).
- Develop a Romanian Action Plan for European mink to share with the Romanian government
- Promote the establishment of a European mink ex situ breeding centre in Romania to the relevant people.

Actions for Cryopreservation and Biobanking

- Find a person to coordinate the different actions going on for Cryopreservation and Biobanking and to work on the following list of actions (Tiit Maran and Madis Põdra).
    - Develop cryopreservation and biobanking protocols for the European mink
    - Receive and discuss the relevant protocols from the Black-footed ferret SSP to determine if these are applicable to European mink
    - Liaise with the EAZA Biobank Working Group to determine how to adapt their general sampling protocol to make it applicable to the European mink.
- Add Tiit Maran to the Black-footed ferret report email list and send the cryopreservation and biobanking protocols to all meeting attendees (Action Paul Marinari)
- Establish a biobank of cryopreserved sperm and other tissues by:
    - Determining what the possibilities are for storage of samples at the Leibniz Institute for Zoo and Wildlife Research (IZW), which is part of the EAZA Biobank.
    - Maintain contact with the National Institute for Agricultural Research (INIA) in Spain to determine what their role can be in the cryopreservation of sperm, storage and possibly other biobanking efforts.
    - Contact Zoo Parc de Beauval (BEAUVAL) about the options for storage of sperm samples at their institution, as this institution is known to already store sperm samples of other species.
    - Continue to store DNA samples at TALLIN for all European mink at this institution.
- Investigate funding options for biobanking, by:
    - Investigating the potential funding options from the Friends Of the National Zoo (FONZ) and Association of Zoos & Aquariums (AZA), both in North America.
    - Finding mutual interest with universities to add a partner to apply for funds for the collection, preservation and use of biobanking samples.

Actions for research on Aggressive/Passive males:

- Discuss the passive/aggressive male issues to identify if any lessons learned with the Black-footed ferret project are applicable to the European mink (Action Paul Marinari and Rachel Santymire)
- Continue to investigate a possible association between aggressive/passive male behaviour and biological variables like the time-sharing of an enclosure by the male and the female, mate-choice, the period of keeping the male and female together to breed, the level of oestrus for females, protein quality in the diet, bacterial fauna of the stomach, zoosemiotics, taurine deposits, hormonal stress levels, or reproductive physiology (Action Tiit Maran and anyone else that wants to be involved).

Population Status
European mink (*Mustela lutreola*) EEP

In situ status

The Critically Endangered European mink was previously native to large parts of Europe, but since the mid-19th century, its numbers in the wild have declined dramatically (IUCN, Maran et al. 2016). The reasons for this decline are, among others, habitat loss and the impact of the invasive American mink that escaped or have been released from American mink farms. Presently, habitat loss and degradation still play a role, but the key problem is the presence and further spread of the American mink near the remaining wild populations of European mink, now facilitated by an increase of American mink farms in Spain and Romania (Maran et al. 2016). The following wild populations remain, based on the meeting attendees' experience:

Estonia: After efforts from the EEP, a small introduced population is surviving on the island Hiiumaa, estimated to be 100 individuals. Currently there are no plans to release additional individuals here, because this is not thought to benefit the demographic stability of the population. Additional releases may happen in the future to increase genetic diversity of this island population. Even though there are no American mink on the island, this population is still under threat due to its small size and possibly low genetic diversity. The plan is to start with the next release operation on the largest Estonian island Saaremaa in the future.

France: There have been no recent exhaustive studies done on the distribution and number of European mink in France. One large scale study has been started in 2016 and the first results are expected in 2019. The population is now estimated at a few hundred individuals, almost surrounded by expanding American mink populations and probably already separated from Spanish wild population of European mink (Pers. Comm. Julien Steinmetz 2017). This population is part of the Western population of European mink, which is thought to have much lower genetic diversity than the Eastern population (Cabria et al. 2015).

Germany: Reintroductions at Steinhuder Meer have resulted in successful breeding in the wild (Brandt 2016).

Romania: The largest verified population of European mink is living in the Danube Delta with a population size estimated to be around 1,000 to 1,500 individuals (Maran et al. 2016). The main threats for this population are invasion by American mink and degradation of habitat. This population is part of the Eastern, more genetically diverse population (Cabria et al. 2015).

Russia: The status of the remaining Russian populations of European mink is unclear, but it is known that the American mink is spreading quickly and these populations are expected to go extinct in the short-term (Maran et al. 2016). Based on camera trap data in 2016, there also seems to be an introduced population on the island of Kunashir in the far East (Skumatov, pers com, 2016). This population is established thousands of kilometers from the known historical range of the European mink.

Spain: It is estimated, based on the capacity of the current distribution area of European mink in Spain, that this population is smaller than 500 individuals, with the main threat for the population being the rapid spreading of the American mink (Põdra & Gomez, pers. Comm. 2017). This population is part of the Western population of European mink which is thought to have much lower genetic diversity than the Eastern population (Cabria et al. 2015).

Ukraine: A small population of European mink was re-discovered in the Danube and Dniester Deltas (de Jongh et al. 2007). Little is known about this population, but it is thought to be under threat of the American mink.

Taxonomic status

Historically at least seven subspecies of European mink have been recognised. However, the European mink is now deemed to be a panmictic species (Youngman 1982; Cabria et al. 2015). There is genetic differentiation between the Eastern (Russian) and Western (Spanish/French) populations (Cabria et al. 2015), which is thought to be an effect of isolation by distance and due to human development. A morphological difference is that a white-patch on the chest is much more common in the Eastern population than in the Western population (Tiit Maran and Madis Põdra, personal communication 2017). This may however just be a result of genetic drift, as the Western population is thought to have gone through a severe bottleneck, resulting in relatively low genetic diversity (Cabria et al. 2015).

Ex situ status

The current EEP population is descended from Russian (Eastern) founders. The only other European mink ex situ population is managed by the Spanish Environmental Ministry and technically assisted by the e. This population is descended from Spanish (Western) founders. In isolation, there is a high risk of losing this Western population due to its small size and low genetic diversity. Merging this population with the EEP population would significantly increase the durability of the Western ex situ population and to a lesser extent that of the current EEP population. Therefore, the aim of the EEP is to incorporate the Spanish breeding programme (Western ex situ population). Whether this will happen, is a political decision that still needs to be made in the future. This plan was nonetheless written under the assumption that will happen at a certain moment in the coming years.
As of 30 April 2017, the total ex situ European mink population consists of 267 individuals, of which 140 are males and 127 are females. These are held at 25 institutions, 14 of which are EAZA institutions and 11 are non-EAZA institutions. Breeding of European mink mainly takes place in specialised breeding centres, but some zoos, such as RIGA, also provide a significant contribution. The largest breeding centres are TALLIN (Tallinn zoo, Estonia), EURONERZ (EuroNerz, Germany), ZOODYSSEE (Zoodyssée, France, under supervision of ONCFS, started in 2016), PONTSUERT (European mink association, Spain) and FIEB (FIEB foundation, Spain, started in 2013).

Because the EEP aims to incorporate the Western ex situ population in the future, population parameters are reported here for the merged population, as well as for the Eastern (current EEP) and Western (Spanish) population separately.

The future roles of the European mink EEP are to

- Maintain a genetically diverse, demographically healthy and behaviourally competent population as a back-up in case all wild populations of European mink go extinct.
- Encourage, support and endorse efforts aimed to restore or establish viable wild populations of European mink in Europe, that are in accordance with the IUCN Translocation Guidelines (IUCN SSC 2013).
- Further integrate in situ and ex situ conservation activities to the benefit of both.
- Be a flagship species and provide conservation education messages for the ecologically important small stream and river ecosystems.
- Educate zoo visitors about the plight of the European mink and the damage of invasive species in general and the American mink in particular.
- Support conservation research on the European mink and encourage public and research institutions to become involved in this. By collecting biomaterials, the EEP also aims to facilitate research in the future.
- Lobby the EU and increase the awareness of other decision makers to produce legislation and policies that favour the conservation status of the European mink.

Institutional holdings

Table 1. Current institutional holdings of European mink under the assumption that the Spanish European mink Association will become a non-EAZA EEP participant. Data are current to 30 April 2017.

Mnemonic	Institution	Country	Male	Female	Total	Membership	Population
AHTARI	Zoo Ahtari	Finland	1	0	1	EAZA	Eastern
BOJNICE	Zoologicka zahrada Bojnice	Slovakia	1	2	3	EAZA	Eastern
CALVIAC	Reserve Zoologique de Calviac	France	3	3	6	EAZA	Eastern
CHOMUTOV	Podkrušnohorský Zoopark Chomutov	Czech Republic	1	1	2	EAZA	Eastern
DECIN	Zoo Decin	Czech Republic	1	1	2	EAZA	Eastern
HELSINKI	Helsinki Zoo	Finland	2	1	3	EAZA	Eastern
JEREZ	ZooBotánico de Jerez	Spain	0	1	1	EAZA	Western
KERKRADE	GaiaZoo, Kerkrade	Netherlands	1	0	1	EAZA	Eastern
MADRID Z	Zoo Aquarium de Madrid (GRPR)	Spain	2	0	2	EAZA	Western
POZNAN	Ogrod Zoologiczny w Poznaniu	Poland	1	1	2	EAZA	Eastern
RANUA	Ranua Wildlife Park	Finland	1	1	2	EAZA	Eastern
RIGA	Riga Zoo	Latvia	5	3	8	EAZA	Eastern
SANTILLAN	Zoo de Santillana	Spain	0	2	2	EAZA	Western
TALLIN	Tallinn Zoo	Estonia	60	46	106	EAZA	Eastern
ZOODYSSEE	Zoodyssée	France	5	4	9	EAZA	Eastern
ADEFFA	Associació de defensa i estudi de la fauna i flora autòctona	Spain	1	3	4	Non-EAZA	Western
ALAVA	Private person	Spain	2	3	5	Non-EAZA	Western
CORDOBA	Municipal Park Zoo	Spain	1	0	1	Non-EAZA	Western
EURONERZ	EuroNerz	Germany	30	28	58	Non-EAZA	Eastern
FIEB	FIEB foundation	Spain	8	9	17	Non-EAZA	Western
HANKENSB	Otter-Zentrum Hankensbüttel	Germany	2	7	9	Non-EAZA	Eastern
PARQNATUR	Parque de la Naturaleza de Navarra	Spain	1	0	1	Non-EAZA	Western
LEDEC	Stanice Ochrony Fauni		1	2	3	Non-EAZA	Eastern
PONTSUERT	Centro de Fauna del Pont de Suert	Spain	7	9	16	Non-EAZA	Western
SACHSEN	Part of Euronerz. Wildtier-und Artenschutzstation	Germany	2	2	4	Non-EAZA	Eastern
WISENTGEH	Part of Euronerz. Wisentgehmut.	Germany	1	0	1	Non-EAZA	Eastern
Total			140	129	269		

Demographic summary

Census

The first record of European mink in zoos was in Berlin Zoo in 1865 and the first recorded captive breeding was in Moscow Zoo in 1933. The first extensive breeding of European mink occurred in NOVOSIBRK in the early 1970s, which resulted in a large amount of useful husbandry information.

In 1984, TALLIN started holding European mink descended from the Eastern population. After several years of slow growth, this population grew rapidly from 65 individuals in 1994 to over 250 individuals in 2000 (Figures 1 and 2). This quick growth was partially due to the establishment of EURONERZ in 1998. Since 2000, the population size stabilised because the available institutional space was saturated (Figure 5). Breeding in the Eastern European mink population has been restricted since the population size reached its capacity in 2000. The population size has oscillated over time, which is partially a result of periodic (re)introduction efforts. In 2016, a third breeding centre was started for Eastern European mink at ZOODYSSEE.

The number of institutions that are holding Eastern European mink peaked in 2000 with around 22 institutions and has since then stabilised at around 17 institutions (Figure 5). The population size of the European mink is mainly dependent on the number of enclosures at the larger breeding centres; About 75% of the Eastern population is kept at EURONERZ and TALLIN, with most other institutions only keeping one to three individuals.

Another European mink population was established in 2004 in Spain from founders of the Western wild population in PONTSUERT and joined by other breeding centres in the years after that. This population grew rapidly to around 65 individuals in 2007 (Figures 3 and 4), after which the population was only allowed to breed at a low rate for several years due to a shortage of institutional space during a period of limited financial means. This became especially problematic in 2010-2013 when most individuals were close to post-reproductive ages. While a population crash was likely at the time, this has fortunately been avoided. Instead, since 2014 the population has slowly started to grow again and the relative number of individuals in the younger age classes has increased significantly.
Currently, there are two centres keeping more than 10 individuals: PONTSUERT and FIEB, which joined the programme in 2013.

The number of institutions that are holding Western European mink increased gradually to 13 institutions in 2014 (Figure 6). Since then, the number of institutions holding Western European mink has decreased because there were fewer post-reproductive individuals sent out from the breeding centre to zoos in recent years.

Table 2. Demographic status of the EEP under the assumption that the Spanish European mink Association will become a non-EAZA EEP participant, current to 30 April 2017.

	Population size (N)*$_1$	Institutions*$_2$
Total population	140.127.0 (267)	25
Eastern population	118.102.0 (220)	17
Western population	22.25.0 (47)	8

*$_1$ Current population size shown as Males.Females.Unknown Sex (Total). *$_2$ Institutions currently holding individuals.

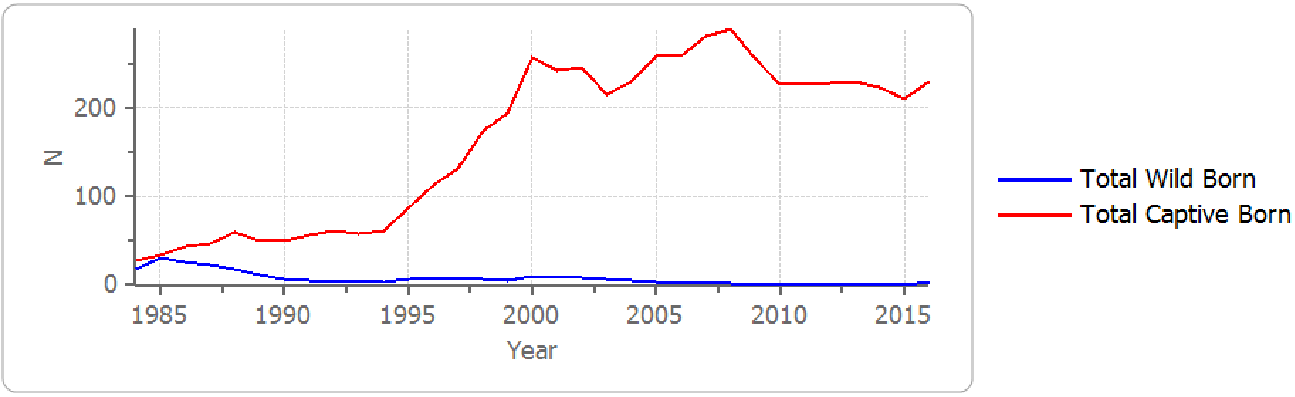

Figure 1: Census by origin, for the Eastern European mink population since 1984.

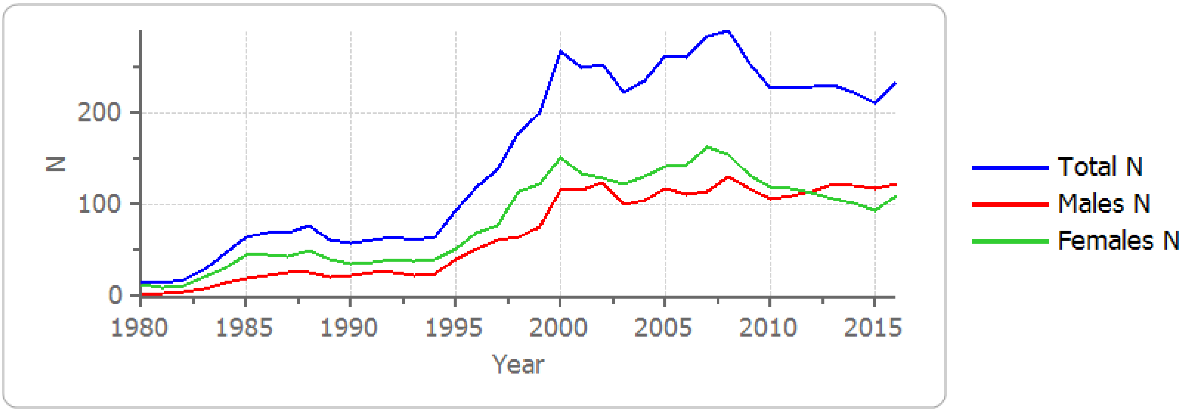

Figure 2: Census, by sex, for the Eastern European mink population since 1980.

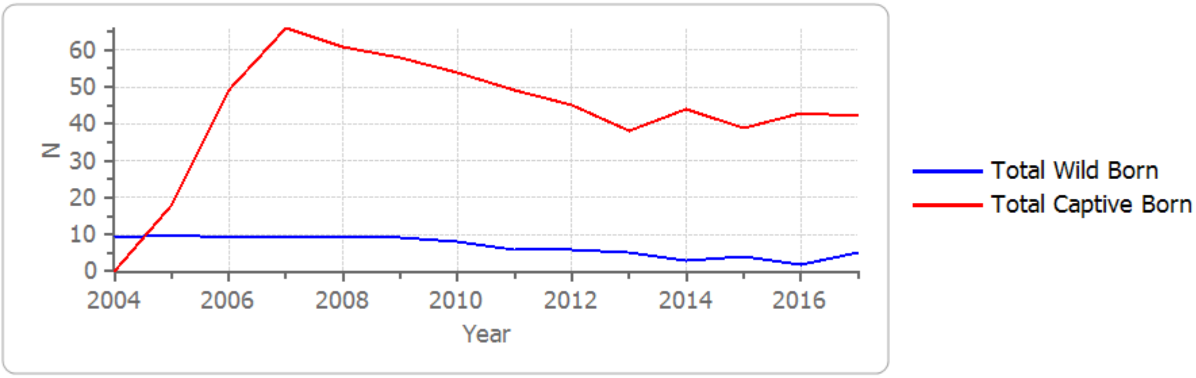

Figure 3: Census by origin, for the Western European mink population since 2004 when the population was established.

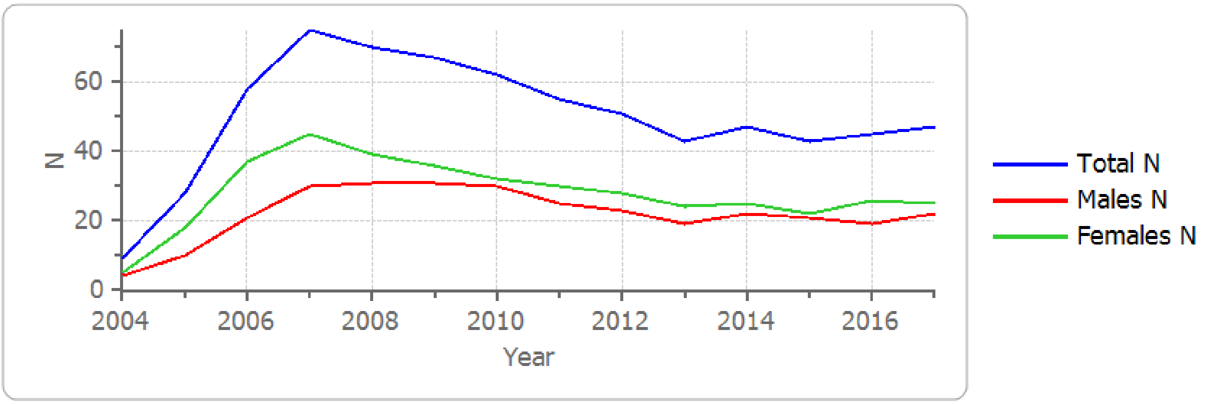

Figure 4. Census, by sex, for the Western European mink population since 2004, when the population was established.

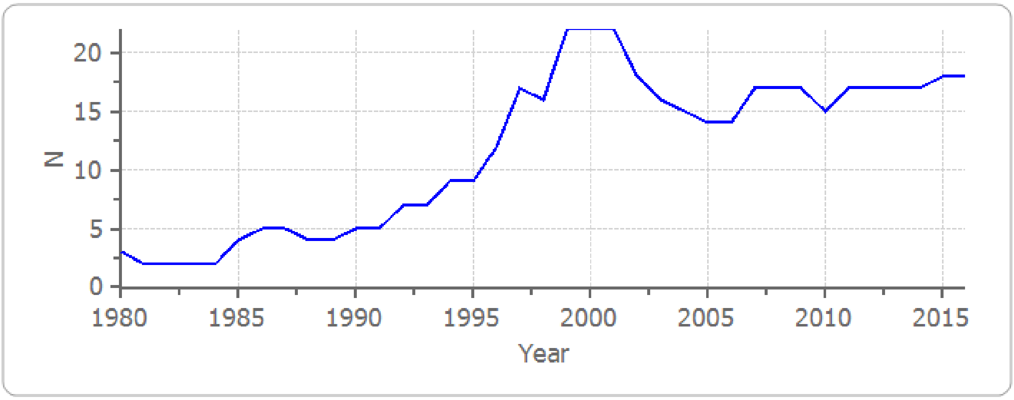

Figure 5: Number of institutions holding European mink of the Eastern population since 1980.

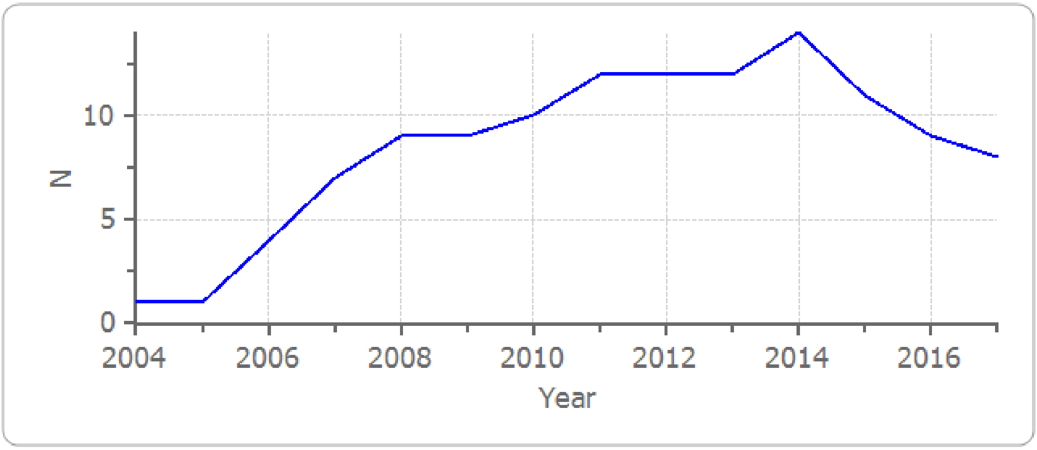

Figure 6: Number of institutions holding European mink of the Western population since 2004.

Age distribution

Positively, there are relatively many individuals in the younger age classes in both the Eastern and the Western population and there are no empty age classes, giving their age distributions somewhat of a pyramid shape (Figures 7 and 8). The Eastern population seems demographically quite robust. However, due to the short generation time of the population this can change if there is little breeding for a few years. The Western population is very sensitive to stochastic events due to its very small size.

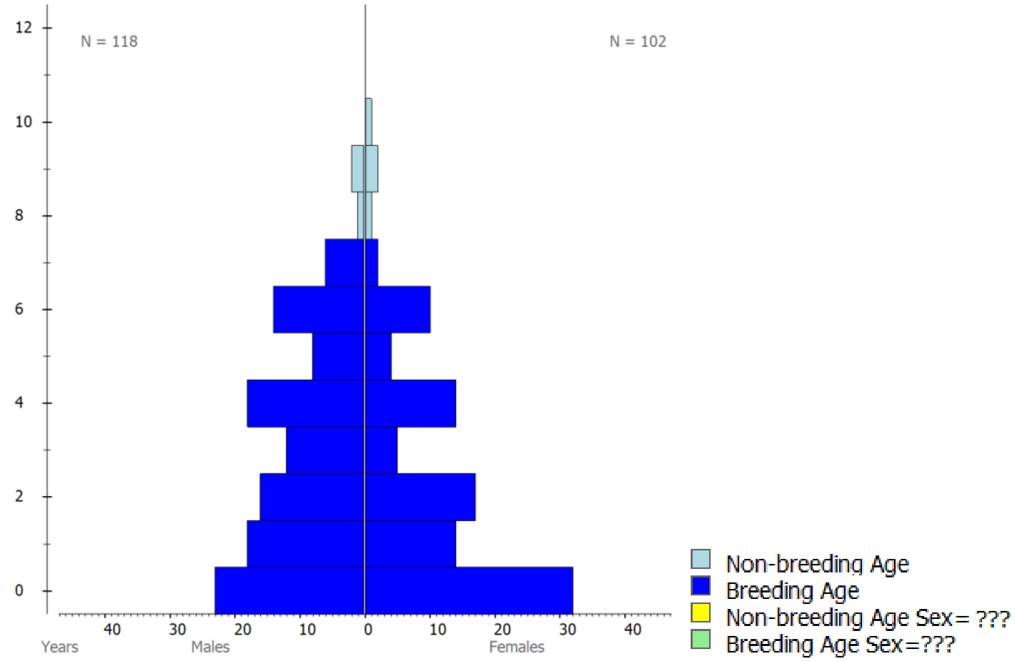

Figure 7: Age distribution of the Eastern population of European mink.

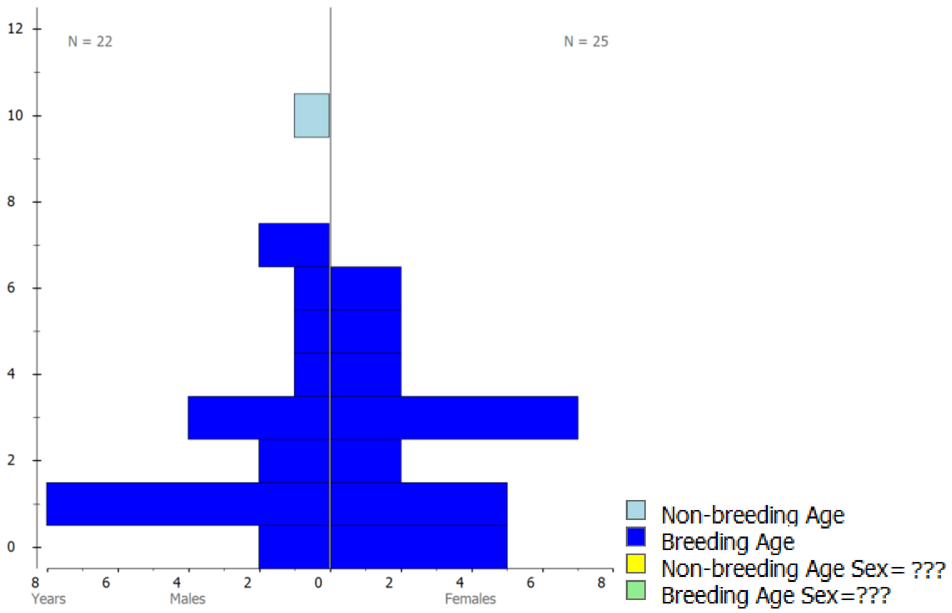

Figure 8: Age distribution of the Western population of European mink

Births, deaths and projections

In the Eastern population, on average in the last five years, there have been 112 births annually (Table 3). This is much higher than the rate of 40 births annually that is projected to be necessary to maintain the population size. The population size would increase drastically (Figure 9), with an increase in size of 31% next year alone (λ= 1.322), if not for the large number of individuals that are released each year.

In the Western population, on average in the last five years, there have been nine births annually (Table 4). This is higher than the seven births annually that are estimated to be needed for population growth. Based on the development of the population since 2004, the population is expected to grow next year by about 7% (λ= 1.067). However, with its small population size, there is a realistic chance that the population will decrease instead of increase (Figure 10). In fact, there is a chance that the population will be lost entirely in about 16 years.

Table 3. Annual births and deaths in the EEP in the Eastern population in the last five years.

Eastern population					
Year	2012	2013	2014	2015	2016
Births	114	120	143	95	90
Deaths	39	52	65	47	49
Number of births per year needed to maintain the population at the current size*$_1$					40

*$_1$ For projections “Birth Flow” in PMx settings was changed from “Continuous” to “Pulse”.

Table 4. Annual births and deaths in the EEP in the Western population in the last five years.

Western population					
Year	2012	2013	2014	2015	2016
Births	4	4	13	10	12
Deaths	10	12	10	15	9
Number of births per year needed to maintain the population at the current size*$_1$					7

*$_1$ For projections “Birth Flow” in PMx settings was changed from “Continuous” to “Pulse”.

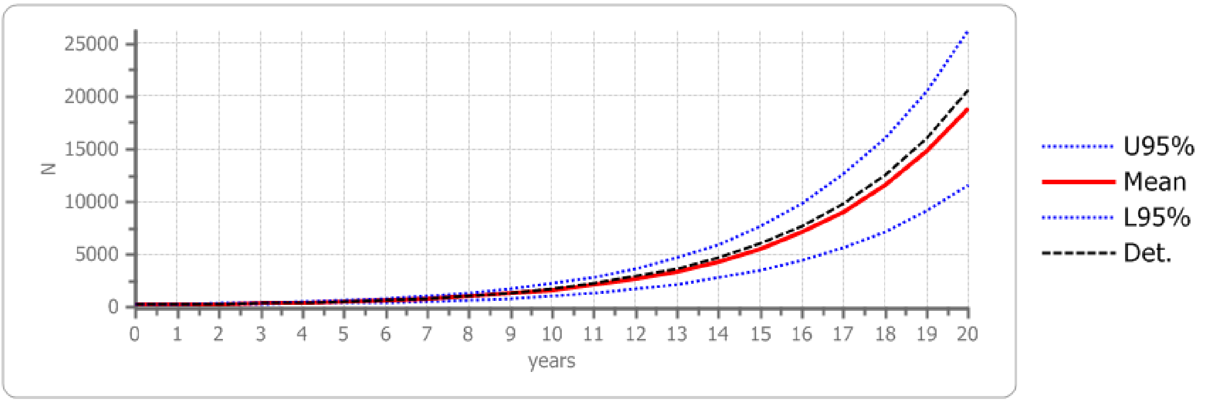

Figure 9. The expected development of the Eastern population based on the current population parameters, assuming there are no reintroductions and no population size limit. For projections “Birth Flow” in PMx settings was changed from “Continuous” to “Pulse”.

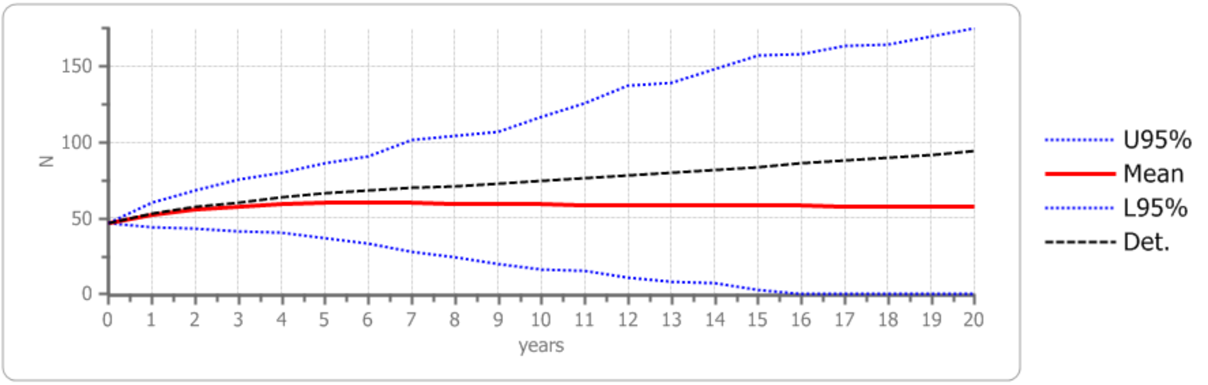

Figure 10. The expected development of the Western population based on the current population parameters, assuming there are no reintroductions and no population size limit. For projections "Birth Flow" in PMx settings was changed from "Continuous" to "Pulse".

Fecundity and Mortality

The European mink (Based on pooled data from the Eastern and Western European mink population, N=1140) is highly seasonal, with 71% of births occurring in May, 28% in June and 1% in April (Figure 11). Very rarely there are also births in July when females fail to breed during the breeding season and come in oestrus a second time. The earliest recorded reproduction is around 11 to 13 months of age. The most fecund ages are one to three years for females and one to four years for males. Reproduction becomes rare after the age of six years. The oldest age of reproduction observed for females is seven years and eight years for males. A large proportion of the captive born males in the population are not able to breed due to behavioural issues, making them too aggressive or passive to breed. This is limiting reproduction and decreases demographic stability of the population.

The average litter size in the Eastern ex situ population is 4.4 kits per litter (Kiik et al. 2017). The average litter size in the EEP may have increased over time, but evaluating this is tricky because data in the past tend to be less complete (See Appendix G Effect of generations in captivity on litter size). Litter size in the Western ex situ population is significantly lower with 2.9 kits per litter (Põdra, pers. comm. 2017).

The generation length, or the average age of reproduction, is 2.2 years for the Eastern population and 2.8 years for the Western population (PMx settings used: Birth flow set on Pulse and Age classes of one month).

Around 18% (N=568) of males and females do not survive the first six months of life. From the age of six months to around four years, mortality rates are around 12% (N=226) per year, after which mortality rates quickly increase, likely because they are nearing their maximum longevity of 10 years. Mortality rates seem to differ per location, likely due to environmental and management differences.

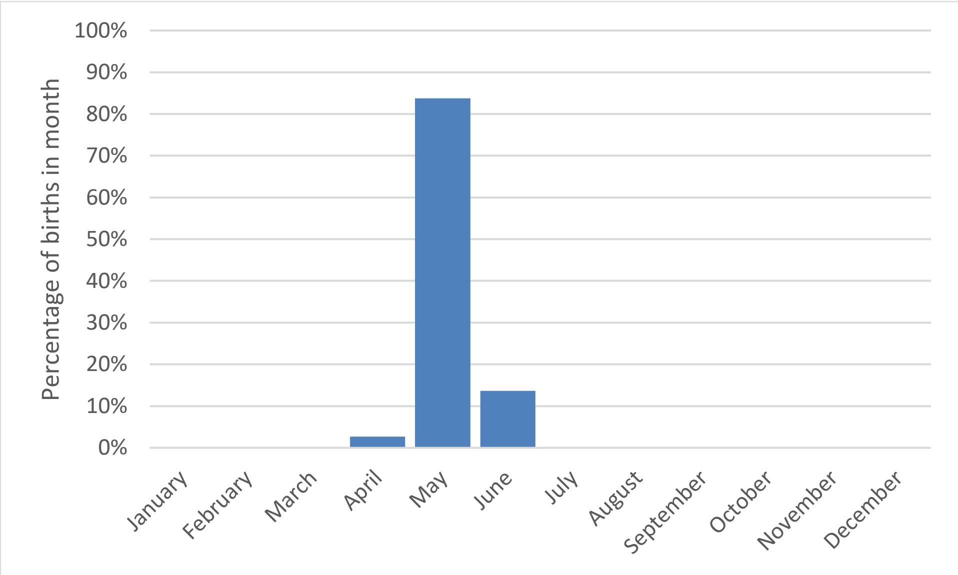

Figure 11: Seasonality of births in the European mink EEP, based on 264 births with a known birth date at TALLIN between 1 January 2010 to 30 April 2017. Months are presented on the x-axis and the % of births in this month on the y-axis. Very rarely there are also births in July when females fail to breed during the breeding season and come in oestrus a second time.

Translocations

The EEP is continuously involved in projects that translocate (both reintroduce and introduce) European mink. To make sure that these are as behaviourally competent as possible to survive and reproduce in the wild, individuals for release are born and raised in semi-wild enclosures. Following the IUCN translocation guidelines (IUCN SSC 2013), the risks involved with any reintroduction in an area where no European mink are currently living will be assessed beforehand. The following (re)introductions efforts have occurred or are planned using European mink from the EEP population or the Spanish Breeding Program:

- **Aragon**, Spain. A first pilot release (assisted colonisation) project will be carried out in the coming years, with ideally around 10 individuals released in 2017 in the upper-course of the Aragon river through the Life Lutreola Spain project.
- **Basque Country and La Rioja**, Spain. Population reinforcement is planned after American mink eradication, which is happening through the Life Lutreola Spain Project. The first releases for this project are planned in 2017.
- **France**. Reintroductions in France, organised through ONCFS, are planned for after 2020. ONCFS is now first investigating the status of the in situ European mink and American mink populations and potential release sites. A prerequisite for reintroductions is that it has been determined that mixing Western and Eastern European mink is without risk, as the French breeding facilities will hold Eastern European mink, while the current wild population is Western European mink (Pers. comm. Julien Steinmetz 2017).
- **Hiiumaa**, Estonia. The introduction of European mink on this island has now led to a permanent population that ranges in size from 50 to 160 individuals, which is estimated to be the capacity of the island. Additional mink may need to be released to increase genetic diversity in the population. It will be evaluated whether this is necessary, likely through molecular genetic analysis.
- **Kunashir and Iturup Islands**, Kuril Archipelago, Russia. Before the establishment of the EEP, the European mink was already introduced on several Russian islands in the 1980s (Maran et al. 2016). There is recent evidence that the population on Kunashir Island (1480 km^2) has survived.
- **Saaremaa**, Estonia. There have been pilot-translocation on this island in 2012. For another series of reintroductions or translocations, funding is needed to finance the activities on Saaremaa.
- **Saarland**, Germany. Reintroduction attempts in the past have not yet led to the establishment of a wild population.
- **Steinhuder Meer**, Germany. The Steinhuder Meer Conservation Station has released a small population here that has successfully reproduced in the wild.

There are likely more locations in Europe with potentially suitable habitat for European mink, but local initiatives are necessary to identify these.
Experience has shown that many European mink generally need to be reintroduced before a wild population is established. It is difficult to predict how many individuals need to be reintroduced before a population can be established, because this is dependent on the ecosystem in which it is reintroduced. It is likely that future reintroductions will be more efficient than past efforts, because a lot has been learned.

Because of the low chance of a reintroduced mink to reproduce in the wild (Maran et al. 2009), generally individuals that are genetically over-represented in the EEP are released, rather than the individuals that would add the most to the genetic diversity of the wild population.

Reintroductions in Spain – Harvest scenarios

It is important that any reintroduction efforts do not hurt the stability of the ex situ population. This is not a serious concern for any reintroduction efforts where the Eastern population is used as a source; the birth rate of the Eastern population is much higher than the rate necessary to maintain population size. Therefore, each year there are many individuals available for reintroduction efforts in Estonia or Germany. For reintroductions in Spain however, currently only individuals from the Western ex situ population are available. Unlike the Eastern population, the Western ex situ population is currently not demographically stable and reintroduction of individuals could cause the Western ex situ population to crash.

To inform future reintroductions, the effect of reintroductions on the population size and birth rate of the Western ex situ population in four years from now was investigated through several simulations. For these simulations, it was assumed that a litter of on average four kits would be reintroduced. Simulations were deterministic and did not consider stochastic factors, therefore the actual development of the population can deviate significantly from the reported results, especially considering the small population size of the Western ex situ population.

The fecundity and mortality rates used to predict the births and deaths in the population in the coming years were based on what has been observed in the Western ex situ population since 1 January 2004. Actual fecundity rates may have improved since then, but there were not sufficient data available to assess this. Based on the Eastern ex situ population, it seems possible for the species to have much higher fecundity rates. If the Western population could improve fecundity, for example by improving husbandry or by bringing in wild-born males, it should be expected that much more individuals could be reintroduced without significantly decreasing the demographic stability of the population.

The current population size is 47 individuals, with an expected birth rate of around 12 births based on the last three years. As can be seen in Table 5 below, if no individuals are reintroduced (Scenario 1), the population will grow to 77 individuals in four years and slightly more births will be produced annually. If, instead, one litter is reintroduced each year (Scenario 2), the population size would still grow slightly, to 49 individuals, but it would result in an aged population with a significant drop in birth rate of only 7 births annually. As could be expected, the later reintroductions are started, the more demographically stable the population will be in four years. If reintroductions of one litter each year are postponed until next year (Scenario 3), the population size would increase to 57 individuals with a birth rate of nine births per year. Postponing reintroductions for two years (Scenario 4), the population size would increase to 65 individuals with a birth rate of ten births per year.

With the current demographic parameters, to maintain a demographically stable population it does not seem desirable to release two litters in several consecutive years. Releasing two litters in one year, however, is less problematic; if two litters are released this year (Scenario 5), the population would grow in four years to 60 individuals, producing an estimated 13 births each year.

In conclusion, any reintroductions of individuals from the Western ex situ population are expected to have a significant impact on demographic stability. In case fecundity rates could be increased to the level of the Eastern population, these results would be much more optimistic. Any reintroductions should be done with caution though, as with this small population size a crash in population size is always realistic. While from a population management perspective it seems better to increase the population to capacity before attempting reintroductions, it may of course be necessary to start earlier with reintroductions due to other factors, such as politics. Simulations should be re-run each year and the actual results will be significantly different due to stochastic effects, and possible due to changes in husbandry.

Table 5. The population size and birth rate expected to be achieved in four years for several different reintroduction scenarios based on simulations.

Scenario	Description	Population size in four years	Average number of births expected per year in year four
1	No reintroductions	77	18
2	Reintroduction of one litter in year 0, 1, 2 and 3	49	7
3	Reintroduction of one litter in year 1, 2 and 3	57	9
4	Reintroduction of one litter in year 2 and 3	65	10
5	Reintroduction of two litters in year 0	60	13

Genetic Summary

Table 6. Genetic status of the European mink EEP population as of 30 April 2017, under the assumption that the Spanish European mink Association will become part of the EEP.

	Eastern*[1]		Western*[2]		Total*[3]	
	Current	Potential	Current	Potential	Current	Potential
Founders	23	0	12	4	35	4
Founder genome equivalents (FGE)	7.3	11.6	1.18	1.5	8.3	13.1
Genetic diversity (GD)	93.2%	95.7%	57.5%	62.5%	94.0%	96.2%
Population mean kinship (MK)	0.068		0.425		0.060	
Mean inbreeding (F)	0.079		0.364		0.136	
Pedigree known before assumptions and exclusions	91.2%		100%		92.8%	
Pedigree known after assumptions and exclusions	91.9%		100%		93.4%	
Effective population size/census size ratio (Ne / N)	0.283		0.073		0.258	
Projections						
Years to 90% Gene Diversity	11		-		16	
Years to 10% Loss from Current Gene Diversity	To 83% GD in 38 years		To 47.5% in 4 years		To 84% in 43 years	
Gene Diversity at 10 generations from present*[4]	87.3%		16.6%		88.6%	
Gene Diversity at 100 Years from present	69.3%		0.7%		72.8%	

*[1] Fifteen individuals were excluded from genetic analysis of the Eastern population: (Appendix C). Projections created in PMx using the following variables, generation time (T)= 2.2 years, Maximum potential lambda (λ)= 1.322 and Target population size (Kt)= 272 based on institutional space (See Demographic goal)
*[2] Three individuals were excluded from genetic analysis of the Western population (Appendix C) and an analytical overlay was used (Appendix A). Projections created in PMx using the following variables, generation time (T)= 2.8 years, Maximum potential lambda (λ)= 1.07 and Target population size (Kt)= 60 based on institutional space (See Demographic goal).
*[3] Eighteen individuals were excluded from genetic analysis (Appendix C) and an analytical overlay was used (Appendix A). Projections created in PMx using the following variables, generation time (T)= 2.3 years, Maximum potential lambda (λ)= 1.26 and Target population size (Kt)= 330, based on institutional space (See Demographic goal).
*[4] With T= 2.2 years for Eastern European mink, ten generations equal 22 years. With T= 2.8 years for Western European mink, ten generations equal 28 years. With T= 2.3 years for the total population, ten generations equal 23 years.

Analytical overlay

To calculate the population genetic parameters of the Western population, an analytical overlay was used, assigning a kinship of 0.375 between all founders originating from the Spanish wild population (Appendix E). This was done because molecular genetic data of wild European mink populations suggests that the Spanish wild population is less genetically diverse than the Russian wild population (Cabria et al. 2015). The EEP aims to verify these molecular genetic results.

Status

Genetic diversity in the Eastern population is 93.2% and theoretically still possible for genetic diversity to increase to 95.7% by breeding by mean kinship because the genetic variation of 11 to 12 founders (Potential FGE= 11.6) is still surviving in the population. The inbreeding coefficient of the population is at a relatively low level of 0.079. The Eastern population can currently be considered as genetically healthy.

This is very different for the genetic diversity in the Western population, which following the above mentioned assumptions, is only 57.5%. By breeding by mean kinship and obtaining new wild founders from the Spanish population, an increase is still theoretically possible to 62.5% genetic diversity. The inbreeding level of the population is estimated to be at 0.364, which is more inbred than the offspring of full siblings. In general, the chance of a significant decrease in fitness becomes higher with increasing inbreeding levels (Charlesworth and Charlesworth 2010).
Currently, only one male that has reproduced is still living (#3189 in PONTSUERT, estimated to be 10 years old, wild caught in 2012), causing the effective population size to only be 0.073 of the actual population size.

Genetic drift
Genetic diversity in the EEP is lost rapidly due to the short generation length of the EEP population (T= 2.2 years) and low proportion of captive born males that are able to breed. Even in the larger and more genetically diverse Eastern population, with the current population parameters, genetic diversity is expected to be reduced to 69.3% in 100 years. When the Eastern and Western population are combined, genetic diversity in this population would increase to 94.0%, with a potential genetic diversity of 96.2%. However, even if this population could also grow to a size of 330 individuals, only 72.8% genetic diversity is maintained in 100 years. The loss of genetic diversity over time can be slowed down by breeding by mean kinship. Currently, the individuals with the lowest mean kinships are part of the Eastern population. The Eastern population should at this time therefore grow relatively more than the Western population.
In order to maintain a genetically healthy EEP population in the long-term (e.g., 100 years), the periodic addition of “new blood” in the EEP is required. There are three options to slow down the decrease of genetic diversity in the population; the continuous addition of new founders, cryopreservation of gametes and exchange with the reintroduced in situ populations.

New founders
The addition of new founders from the Eastern wild population would allow a significant increase in genetic diversity. This effect is much smaller for the addition of new founders from the Western wild population, because of the low genetic diversity in the wild population and the 12 Western founders that are already represented. Nevertheless, wild-born males will likely be demographically important for the population, as these males are more likely to breed successfully.

The last remaining wild populations are small, with many having a size of only a few hundred individuals (Maran et al. 2016). Generally, genetic diversity in small populations is lost even more rapidly in the wild than when managed appropriately in captivity (Frankham et al. 2010). These populations should therefore be anticipated to also have increasingly less genetic diversity.

Cryopreservation
Cryopreservation of sperm that can be used several decades later to inseminate females is theoretically the most promising method of maintaining genetic diversity for the long-term. Currently, the genetic variation of 13 unrelated founders is still surviving in the ex situ population (Potential FGE= 13.0). A large part of this genetic variation in the EEP will be lost in the coming decades by genetic drift, but this could theoretically be returned to the EEP population if sperm, oocytes or embryos are cryopreserved.

Ideally, the genetic variation of at least 20 founders would be maintained in the EEP population for a proper back-up of the species' genepool (Frankham et al. 2010). While this may not be possible in practice, this is theoretically currently still possible through a combination of cryopreservation and new founders from any of the Eastern wild populations, of which Romania is the most likely candidate.

Exchange between ex situ and in situ

For genetic reasons, exchange between in situ and ex situ populations is not per se necessary as long as inbreeding levels do not become too high in any of the populations. For demographic reasons, however, wild-born males that descend from reintroduced EEP individuals are planned be added to the ex situ population periodically. This adds a complexity to genetic management because it is not known from which reintroduced individuals these males descend. This situation could theoretically be solved through the use of molecular genetic analysis. This would only make sense though if results can be compared to the individuals that were reintroduced so that the missing part of the pedigree can be reconstructed. With an increasing number of generations since reintroduction, more detailed molecular genetic tests will be necessary. Alternatively, this situation can be solved by using MULTs or an analytical overlay. In this case, it would be assumed that all reintroduced individuals equally contributed to the genetic makeup of the individual. This will lead to less accurate results than molecular genetic analysis, but is also significantly less costly.

Goals and reproductive strategy

Western and Eastern population

While this requires approval from the Spanish government, the aim of the EEP is to include the Western ex situ population and to manage it as one combined population with the Eastern populations. The reasoning behind this is the following: The Western population currently has very low genetic diversity and due to its small size, is very sensitive to stochastic events. The chance of losing the unique genetic variation found in the Western population would decrease if these would be held in more institutions and if there would be more options to minimise inbreeding. Also, mixing with the Eastern population will increase the fitness of the population held at Spanish (Western) institutions, making them a better source for reintroduction. Moreover, with a combined population, more genetic variation can be maintained than separate Eastern and Western populations can. Combining the two populations thus improves the value of the ex situ European mink population as a back-up for reintroductions in the future.

Whether the Western ex situ population will indeed become part of the EEP depends on the decision of the Spanish government. If so, merging the two populations is planned to be done in phases. In the first phase, about six individuals (three males and three females) will be exchanged between the Spanish European mink Association and the current EEP institutions to be bred with their Eastern or Western counterparts at both institutions in 2018. The offspring will be monitored closely to identify if there are any signs of outbreeding depression. In the second phase, the Western and Eastern population will be mixed on a larger scale. In the third phase, individuals will be bred and transferred, as makes sense for the population as one taxonomical unit that is nevertheless still managed as several sub-populations (See Sub-populations below)

Demographic goal

European mink populations are sensitive to stochastic demographic events due to the short generation time, but fortunately the EEP population is reasonably large and very fecund. The largest demographic risks are the low proportion of captive born males that can breed and the limited number of breeding centres that are also sensitive to political changes and catastrophic events.

The demographic goal of the EEP is to grow the population where possible and include a higher number of institutions that are able to breed. At this time, it is still possible for the ex situ population to grow. In addition to the current 47 individuals, the Spanish breeding centres can keep at least another 19 individuals, reaching a total of 66 individuals in Spain, excluding the space at the eight pre-release enclosures. In addition to the 220 individuals at institutions currently holding European mink, there is still capacity for another 52 individuals at ZOODYSSEE, increasing to a population size of 272 individuals. This brings the demographic goal of the EEP population, based on available institutional space, to a population size of around 330 individuals.

Genetic goal

A back-up population ideally captures most of the genetic diversity of the wild population. In order to catch most of the heterozygosity of a population, the genetic diversity of 20-30 founders is needed (Frankham et al. 2010). Because 20 founders equal 97.5% genetic diversity, the ideal for a back-up population is to maintain at least 97.5% potential genetic diversity in the population. While it is unlikely that the EEP will achieve this goal, it is not necessarily impossible if all efforts are successful.

To achieve this goal, the EEP aims to:

- Manage the ex situ population by mean kinship, prioritising individuals with low mean kinship for breeding and pairing individuals with similar mean kinships.
- Obtain new founders from the Spanish wild population, which is a source from which new founders can be obtained with an expected frequency of one to two founders every two years (Pers. comm. Madis Põdra 2017). However, these founders' genetic contribution to the EEP is minimal if genetic diversity in the Western wild population is indeed as low as estimated by Cabria et al. (2015).
- Obtain new founders from the Romanian wild population. Because it is unlikely, due to political factors, to obtain European mink from the Russian or Ukrainian populations, the Romanian population is the most realistic source for new founders for the Eastern population of the EEP. The founders of this population could provide a significant genetic contribution to the population, as this wild population is genetically diverse and carries a number of unique alleles that are not captured with the Russian founders of the EEP population (Cabria et al. 2015). Obtaining Romanian founders needs to happen as soon as possible, as the current increase in American mink farming in Romania, could lead to the disappearance of this wild population with all its unique genetic variation. Currently, the Romanian government does not allow capturing European mink. This situation could change if there would be a Romanian Action Plan for European mink developed and an ex situ breeding centre developed in Romania. A European mink working group is planned to be established that will work on this together with Romanian zoos, the Romanian Zoo and Aquaria Federation (RZAF) and the Danube Delta Research Institute.
- Monitor any political changes that may allow obtaining founders from the Russian, Ukrainian or French wild populations. The Russian Caucasus wild populations can provide a large genetic contribution to the EEP population, as these are not closely related to the other Russian founders already being represented in the population and because this wild population is expected to be genetically very diverse (Cabria et al. 2015). This is true to a lesser degree for the Ukrainian wild population, which is expected to be related to the Romanian wild population. Founders from the French wild population are likely only able to provide a modest genetic contribution to the EEP population because of the low genetic diversity in this population and because these are closely related to the Spanish founders (Cabria et al. 2015). Moreover, the scientific community in France is reluctant to consider removal from the wild (Pers. comm. Julien Steinmetz 2017). Therefore, it is unlikely that new founders can be obtained from either of these populations in the foreseeable future due to political and bureaucratic factors.
- Work towards the large-scale cryopreservation of European mink sperm to allow insemination of females in the future. This may include obtaining sperm of wild European mink that are caught during monitoring surveys. There already have been some experiments with cryopreservation of sperm in the past. The EEP will first develop protocols for cryopreservation, taking advantage of the protocols that have already been successfully developed for AZA's Black-footed ferret SSP. This will be part of the larger biobanking efforts for the European mink (See below).

Biobanking

In addition to cryopreservation of sperm, the EEP aims to store DNA samples and other biomaterials to facilitate research in the future. Similar to the cryopreservation protocols, the EEP will develop protocols for collecting biomaterials, taking advantage of the already existing protocols used by the Black-footed ferret SSP and the EAZA Biobanking Working Group. Collaboration will be sought with the National Institute for Agricultural Research in Spain, ZooParc de Beauval (BEAUVAL), IZW as part of the EAZA Biobank and interested universities. Funding will need to be found for the supplies and long-term storing and curating of samples.

Sub-populations

To decrease paperwork and costs, the EEP aims to manage the population as several sub-populations based on geography of the ex situ institutions, where transfers occur on a more local level. Currently, these sub-populations are one in Spain, one in France, one in Northern Europe and one in Central Europe. Of course, there will also periodically be transfers between the different sub-populations. The details of how management will be organised still need to be further developed.

Aggressive/passive males

Because of the large proportion of captive born males that are not able to breed due to aggressive or passive behaviours towards the female, the EEP population is demographically less stable and maintains less genetic diversity. Despite the large amount of physiological and genetic research done on this topic, the cause of this behaviour is not yet known. Wild-born males in the EEP have not been observed to show this behaviour.

Ongoing and future research on this topic should examine the effect of potential variables and a combination of these variable including more accurately defining the right level of oestrus for females, improving protein quality in the diet, investigating the effect of a change in stomach bacterial fauna in captivity, zoosemiotics, taurine deposits and hormonal stress levels, and further research on reproductive physiology. Until then, the problem can be mitigated by bringing in wild-born males to breed with captive-born females. For example, wild-born males could be obtained from the Spanish wild population or the reintroduced wild population on Hiiumaa. However, before individuals are obtained from the Hiiumaa population for this purpose, a protocol needs to be developed to make sure that is done with minimum risk for the in situ and ex situ population.

Awareness raising

The European mink is not well-known by European governments and receives significantly less attention and funds for conservation than many other non-threatened European species. This is likely one of the reasons why the American mink has not yet been placed on the Alien Invasive Species List. For example, the needs of the European mink were ignored when the American mink was not placed on the European Union's Alien Invasive Species list. The EEP believes that the best way to improve this situation is by raising awareness of the critical state of the European mink in the wild in the most essential governments, France, Spain, Romania Estonia, Germany and the European Union, as well as the general public. Activities that will (continue to) be carried out are:

- Organise European Mink Day (23 April) with schools, zoos and aquaria. For this, the EEP aims to have a much wider involvement.
- Share a yearly newsletter reporting the progress made with the European mink EEP and in situ efforts.

- Assign an Education Advisor that will focus on the European mink
- Continue to advertise the Foundation Lutreola on Facebook and keep sharing the short European mink movie.
- Continue discussing the situation of the European mink with the EAZA European union lobbyist to determine opportunities to educate decision makers.
- Work with the French Association of Zoos (AFdPZ) to directly educate French decision makers.
- Work with the Iberian association of Zoos and Aquaria (AIZA) to continue to encourage actions on European mink education in Spain, such as a campaign on European mink as was done previously.

Conclusions for European mink

- The Western and Eastern ex situ populations will eventually be managed as one combined population under the umbrella of the EEP. It will take several years before breeding between the two populations is expected to happen on a large scale.
- The ex situ European mink population is demographically reasonably stable and planned to grow slightly in the coming years to a population size of 330 individuals based on available institutional space. The large proportion of males that are not able to breed due to aggressive or passive behaviour poses a demographic risk. Therefore, the EEP will investigate why these males are exhibiting these unusual behaviours.
- There are currently only five institutions that can breed a significant number of European mink. The uncertainty of future funds for some of these institutions poses a risk for the ability of the EEP to maintain the current population size. Therefore, a larger number of institutions that can contribute to breeding, which requires keeping at least 10 European mink, are necessary for the EEP's long-term stability.
- The Western ex situ population has very low genetic diversity, following Cabria et al. (2015). Exchange with the Eastern ex situ population is therefore important on the short-term to avoid inbreeding depression. The Eastern ex situ population is currently still genetically healthy. However, due to the short generation time of the European mink, genetic diversity is lost rapidly from the population. In order to reach its genetic goal to maintain a population with a potential genetic diversity of 97.5% for as long as possible, the EEP will work on:
  - Breeding the EEP population by mean kinship
  - Obtaining new founders from any wild population, in particular the genetically diverse Romanian wild population, and
  - Cryopreservation of sperm so that genetic diversity that is lost from the population can be returned to the population in the future.
- To facilitate research in the future, the EEP will support biobanking on a large scale, once funds have been found for this.
- Sub-populations of captive European mink will be organised to decrease costs and travel-time for European mink transfers.
- The EEP will continue to increase awareness about the European mink to governmental decision makers and the general public, as this is deemed to be essential for improving the

situation of the European mink wild populations as well as for maintaining the EEP population in the long-term.

- This population will be re-evaluated annually by the European mink EEP Coordinator and Species Committee.
- Once the EEP has been able to re-organise, institutional breeding recommendations will be developed by the EEP Coordinator together with the Coordinator of the relevant sub-population and provided by the Coordinator of the relevant sub-population.

Appendix A
Pedigree assumptions

There is evidence that the genetic diversity in the Western wild population is significantly lower than in the Eastern one (Cabria et al. 2015). To be exact, based on 11 microsatellite markers, heterozygosity in the wild Spanish (Western) source population of the founders of the Western ex situ population is estimated to be 0.353, which is significantly lower than the 0.619 found for the wild Russian wild population, which is the source of the founders of the Eastern ex situ population. The study also shows genetic differentiation between the two wild populations, caused by a lack of diversity of the Spanish wild population, not by a high number of unique alleles found in the Spanish population.

Because of the Russian (Eastern) wild population's higher genetic diversity, Russian founders are expected to be more genetically valuable to the EEP than Spanish (Western) founders. The genetic diversity of the Spanish wild population is only 57% of that of the Russian wild population (expected heterozygosity in the Spanish wild population is 0.353, compared to 0.619 in the Russian wild population). Following this, individuals in the Spanish wild population are estimated to have a kinship of roughly 0.43 with each other, relative to the Russian wild population. To simulate this, an analytical overlay was used. A relatively easy way to assign a kinship of 0.43 to all Spanish founders was to assign all Spanish founders the same parents, HYP002 and HYP003, where HYP002 and HYP003 were also assigned the same parents, WILD1 and WILD2. This resulted in a kinship between all Spanish founders of 0.375. While this is 0.055 less than the 0.43 found in Cabria et al. (2015), this difference was not thought to be significant for this exercise. This assumption results in a maximum genetic diversity of 62.5% that can be achieved with founders from the Spanish wild population only. Currently, this overlay does not consider differentiation between the two populations.

OVERLAY REPORT

EUROPEAN MINK ***Mustela lutreola novikovi***

CHANGES MADE IN OVERLAY: "SPAINF"

STUD ID	CHANGES	NOTES
1640	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1641	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1642	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1643	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1644	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1645	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1646	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	
1647	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003	

1648	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
1667	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3189	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3194	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3212	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3213	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3285	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3286	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3287	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003
3288	Change Sire ID from: WILD to: HYP002 Change Dam ID from: WILD to: HYP003

HYP002	Create Hypothetical Ancestor: HYP002 Captive Born at: UNKNOWN On: 01 Jan 1900 U Sex: Male Sire: WILD1 Dam: WILD2 Transfer to: UNKNOWN On: Current Status: LTFU
HYP003	Create Hypothetical Ancestor: HYP003 Captive Born at: UNKNOWN On: 01 Jan 1900 U Sex: Female Sire: WILD1 Dam: WILD2 Transfer to: UNKNOWN On: Current Status: LTFU

Appendix B
Summary of Data Exports

Export for Demographic and Genetic Analysis of the Eastern population

PMx Project	MinkEast2010 Updated May 2017
Created	2017-05-29 by PMx version 1.4.20170317
File	C\PMxProjects\MinkEast2010 Updated May 2017.pmxproj
Primary data file	
Data File Name	EXCHANGE.CSV
LUTRE3 input file for pmx	
Scientific name	MUSTELA LUTREOLA NOVIKOVI
Common name	EUROPEAN MINK
Exported on	29/05/2017
Software version	Sparks 1.66
Scope	European regional
Current to	30/04/2017
Compiled by	Tiit Maran, Tallinn Zoo, tiit.maran@tallinnlv.ee
Filter conditions in effect	
Dates	01/01/2010 <= 28/05/2017
User Defined Fields	"EAST" $ upper(SUBPOP)

Export for Demographic Analysis of the Western population

PMx Project	MinkWest2004 Updated May 2017
Created	2017-05-29 by PMx version 1.4.20170317
File	C \PMxProjects\MinkWest2004 Updated May 2017.pmxproj
Primary data file	
Data File Name	EXCHANGE.CSV
LUTRE3 input file for pmx	
Scientific name	MUSTELA LUTREOLA NOVIKOVI
Common name	EUROPEAN MINK
Exported on	29/05/2017
Software version	Sparks 1.66
Scope	European regional
Current to	30/04/2017
Compiled by	Tiit Maran, Tallinn Zoo, tiit.maran@tallinnlv.ee
Filter conditions in effect	
Dates	01/01/2004 <= 25/05/2017
User Defined Fields	"WEST" $ upper(SUBPOP)

Export for Genetic Analysis of the Western population

PMx Project	MinkAnalytical June 2017
Created	2017-05-29 by PMx version 1.4.20170317
File	C\PMxProjects\MinkAnalytical June 2017.pmxproj
Primary data file	
Data File Name	EXCHANGE.CSV
XXMINK4 input file for pmx	
Scientific name	MUSTELA LUTREOLA NOVIKOVI
Common name	EUROPEAN MINK
Exported on	29/05/2017
Software version	Sparks 1.66
Scope	Analysis Set Created by SPARK-plug
Current to	30/04/2017
Compiled by	Tiit Maran
Filter conditions in effect	
Dates	01/01/2010 <= 28/05/2017
User Defined Fields	"WEST" $ upper(SUBPOP)

Export for Genetic Analysis of the entire EEP population

PMx Project	MinkAnalytical June 2017
Created	2017-05-29 by PMx version 1.4.20170317
File	C\PMxProjects\MinkAnalytical June 2017.pmxproj
Primary data file	
Data File Name	EXCHANGE.CSV
XXMINK4 input file for pmx	
Scientific name	MUSTELA LUTREOLA NOVIKOVI
Common name	EUROPEAN MINK
Exported on	29/05/2017
Software version	Sparks 1.66
Scope	Analysis Set Created by SPARK-plug
Current to	30/04/2017
Compiled by	Tiit Maran
Filter conditions in effect	
Dates	01/01/2010 <= 28/05/2017

Appendix C
Animals Excluded from Genetic Analysis

ID	Location	Local ID	Sex	Population	Reason for exclusion
1831	HANKENSB	F340	Female	Eastern	Old age
2057	HANKENSB	M442	Male	Eastern	Old age
2059	WISENTGEH	M444	Male	Eastern	Old age
2066	HANKENSB	F451	Female	Eastern	Old age
2080	HANKENSB	F454	Female	Eastern	Old age
2128	TALLIN	16966	Male	Eastern	Old age
2139	BOJNICE	M01034	Female	Eastern	Old age
2318	TALLIN	17326	Female	Eastern	Old age
2321	TALLIN	17329	Female	Eastern	Old age
2325	TALLIN	17333	Male	Eastern	Old age
2406	EURONERZ	M604	Male	Eastern	Old age
2433	EURONERZ	M631	Male	Eastern	Old age
2444	EURONERZ	M642	Male	Eastern	Old age
2446	EURONERZ	M644	Male	Eastern	Old age
2448	EURONERZ	M646	Male	Eastern	Old age
2388	PONTSUERT	F515	Male	Western	Old age
3179	PARQNATUR	F601	Male	Western	Old age
3189	PONTSUERT	F801	Male	Western	Old age

Appendix D
Life Tables

- For EEP population –

Note that the reported mortality and fecundity rates are always a result of a combination of the biology of the species and historical management and that especially data on older ages becomes less reliable due to a smaller sample size.

Eastern population

Males				
Age	Qx	Lx	Mx	Sample size
0	0.21	1.00	0.24	222
1	0.08	0.79	0.62	153
2	0.08	0.72	0.56	147
3	0.09	0.67	0.52	126
4	0.13	0.61	0.33	107
5	0.23	0.53	0.43	75
6	0.24	0.41	0.16	52
7	0.32	0.31	0.13	25
8	0.56	0.21	0.00	9
9	0.61	0.09	0.00	4
10	0.00	0.04	0.00	1
11	1.00	0.00	0.00	0

Females				
Age	Qx	Lx	Mx	Sample size
0	0.24	1.00	0.31	233
1	0.12	0.76	0.83	128
2	0.10	0.68	0.44	112
3	0.12	0.61	0.51	102
4	0.16	0.53	0.48	100
5	0.16	0.45	0.42	77
6	0.15	0.37	0.22	60
7	0.25	0.32	0.04	30
8	0.34	0.24	0.00	16
9	0.45	0.16	0.00	9
10	0.49	0.08	0.00	4
11	1.00	0.00	0.00	0

Western population

Males				
Age	Qx	Lx	Mx	Sample size
0	0.15	1.00	0.10	60
1	0.06	0.85	0.42	52
2	0.07	0.80	0.33	45
3	0.11	0.74	0.34	36
4	0.07	0.66	0.10	29
5	0.07	0.62	0.27	28
6	0.28	0.57	0.18	23
7	0.31	0.41	0.28	13
8	0.40	0.28	0.00	7
9	0.83	0.17	0.00	3
10	1.00	0.00	0.00	0
11	1.00	0.00	0.00	0

Females				
Age	Qx	Lx	Mx	Sample size
0	0.13	1.00	0.06	78
1	0.05	0.87	0.32	64
2	0.07	0.83	0.41	57
3	0.13	0.77	0.34	44
4	0.08	0.67	0.19	37
5	0.06	0.62	0.07	35
6	0.18	0.59	0.02	26
7	0.41	0.48	0.00	17
8	0.36	0.28	0.00	12
9	0.47	0.18	0.00	7
10	1.00	0.10	0.00	0
11	1.00	0.00	0.00	0

Appendix E
Ordered Mean Kinship list

Population mean kinship= 0.061

Males					
ID	MK	Age	Location	%known	Population
3224	0.028	1	TALLIN	98%	Eastern
2519	0.040	7	SACHSEN	93%	Eastern
2514	0.042	7	SACHSEN	87%	Eastern
2567	0.043	6	TALLIN	97%	Eastern
2568	0.043	6	TALLIN	97%	Eastern
2492	0.044	7	TALLIN	97%	Eastern
2490	0.044	7	BOJNICE	97%	Eastern
2504	0.045	7	TALLIN	100%	Eastern
2478	0.046	7	TALLIN	94%	Eastern
2476	0.046	7	RIGA	94%	Eastern
2485	0.048	6	TALLIN	94%	Eastern
2473	0.048	7	RIGA	97%	Eastern
2700	0.048	4	TALLIN	98%	Eastern
2663	0.048	6	HANKENSB	73%	Eastern
2679	0.050	5	TALLIN	100%	Eastern
2898	0.050	4	EURONERZ	83%	Eastern
2570	0.050	5	TALLIN	97%	Eastern
2561	0.051	6	TALLIN	97%	Eastern
2560	0.051	6	CALVIAC	97%	Eastern
2682	0.051	5	TALLIN	95%	Eastern
2683	0.051	5	TALLIN	95%	Eastern
2707	0.051	4	TALLIN	94%	Eastern
2974	0.051	3	CHOMUTOV	94%	Eastern
2726	0.051	5	RANUA	94%	Eastern
2728	0.051	5	HELSINKI	94%	Eastern
2975	0.051	3	AHTARI	94%	Eastern
2801	0.051	4	CALVIAC	95%	Eastern
2803	0.051	4	POZNAN	95%	Eastern
2670	0.051	5	TALLIN	95%	Eastern
3044	0.052	1	PAVLOV	95%	Eastern
3045	0.052	1	TALLIN	95%	Eastern
2780	0.052	4	TALLIN	94%	Eastern
2781	0.052	4	TALLIN	94%	Eastern
2783	0.052	4	HELSINKI	94%	Eastern
2808	0.052	3	RIGA	98%	Eastern
2930	0.052	3	DECIN	97%	Eastern
2929	0.052	3	TALLIN	97%	Eastern
2931	0.052	3	TALLIN	97%	Eastern
2932	0.052	3	TALLIN	97%	Eastern

Females					
ID	MK	Age	Location	%known	Population
3226	0.028	1	ZOODYSSEE	98%	Eastern
2581	0.042	6	SACHSEN	90%	Eastern
2517	0.042	7	SACHSEN	87%	Eastern
2468	0.046	7	BOJNICE	94%	Eastern
2697	0.046	4	RIGA	94%	Eastern
2978	0.046	3	RANUA	92%	Eastern
2979	0.046	3	POZNAN	92%	Eastern
2661	0.048	6	HANKENSB	72%	Eastern
2662	0.048	6	HANKENSB	72%	Eastern
2664	0.048	6	HANKENSB	73%	Eastern
2685	0.049	5	CALVIAC	95%	Eastern
2665	0.049	6	HANKENSB	73%	Eastern
2475	0.049	7	PAVLOV	97%	Eastern
2687	0.049	5	TALLIN	95%	Eastern
2695	0.050	4	TALLIN	94%	Eastern
2692	0.050	4	CALVIAC	97%	Eastern
2688	0.051	5	TALLIN	95%	Eastern
2977	0.051	3	DECIN	94%	Eastern
2976	0.051	3	PAVLOV	94%	Eastern
2802	0.051	4	TALLIN	95%	Eastern
2673	0.051	5	TALLIN	95%	Eastern
2689	0.052	4	RIGA	97%	Eastern
3043	0.052	1	TALLIN	95%	Eastern
2785	0.052	4	ZOODYSSEE	94%	Eastern
2494	0.052	6	TALLIN	97%	Eastern
2727	0.052	5	TALLIN	94%	Eastern
2800	0.052	4	ZOODYSSEE	95%	Eastern
2470	0.052	7	TALLIN	94%	Eastern
2933	0.052	3	TALLIN	97%	Eastern
3050	0.053	2	TALLIN	96%	Eastern
3062	0.053	2	TALLIN	95%	Eastern
2714	0.053	4	CALVIAC	100%	Eastern
2716	0.053	4	RIGA	100%	Eastern
3051	0.053	1	TALLIN	97%	Eastern
3052	0.053	1	TALLIN	97%	Eastern
2948	0.053	2	TALLIN	97%	Eastern
2949	0.053	2	TALLIN	97%	Eastern
2771	0.054	4	EURONERZ	81%	Eastern
2923	0.054	3	TALLIN	95%	Eastern

Males						Females					
ID	MK	Age	Location	%known	Population	ID	MK	Age	Location	%known	Population
2782	0.053	4	TALLIN	94%	Eastern	2924	0.054	3	TALLIN	95%	Eastern
2927	0.053	3	TALLIN	98%	Eastern	2619	0.054	5	EURONERZ	78%	Eastern
2925	0.053	3	RIGA	98%	Eastern	2690	0.054	4	TALLIN	97%	Eastern
2926	0.053	3	RIGA	98%	Eastern	2546	0.054	7	EURONERZ	80%	Eastern
3064	0.053	2	TALLIN	95%	Eastern	2643	0.054	5	EURONERZ	80%	Eastern
3065	0.053	2	TALLIN	95%	Eastern	3046	0.055	2	TALLIN	95%	Eastern
3066	0.053	2	TALLIN	95%	Eastern	3068	0.055	2	TALLIN	95%	Eastern
2577	0.053	5	TALLIN	95%	Eastern	3069	0.055	2	TALLIN	95%	Eastern
3053	0.053	1	TALLIN	97%	Eastern	3147	0.055	1	TALLIN	95%	Eastern
3054	0.053	1	TALLIN	97%	Eastern	3148	0.055	1	TALLIN	95%	Eastern
2564	0.053	6	TALLIN	98%	Eastern	3149	0.055	1	TALLIN	95%	Eastern
2922	0.054	3	TALLIN	95%	Eastern	2633	0.055	6	EURONERZ	85%	Eastern
2810	0.054	3	TALLIN	98%	Eastern	3237	0.055	1	EURONERZ	81%	Eastern
2691	0.055	4	TALLIN	97%	Eastern	3238	0.055	1	EURONERZ	81%	Eastern
3048	0.055	2	TALLIN	95%	Eastern	2787	0.056	4	TALLIN	97%	Eastern
3049	0.055	2	TALLIN	95%	Eastern	2811	0.056	3	TALLIN	95%	Eastern
2510	0.055	6	TALLIN	97%	Eastern	2928	0.056	3	TALLIN	98%	Eastern
2669	0.055	5	TALLIN	95%	Eastern	3253	0.056	0	EURONERZ	77%	Eastern
2680	0.055	5	TALLIN	100%	Eastern	3055	0.057	2	TALLIN	97%	Eastern
3145	0.055	1	TALLIN	95%	Eastern	2982	0.058	3	EURONERZ	81%	Eastern
2559	0.055	6	CALVIAC	94%	Eastern	2944	0.058	3	CHOMUTOV	97%	Eastern
3146	0.055	1	ZOODYSSEE	95%	Eastern	2945	0.058	3	TALLIN	97%	Eastern
2666	0.056	5	TALLIN	97%	Eastern	3122	0.059	2	EURONERZ	81%	Eastern
3056	0.057	2	TALLIN	97%	Eastern	3245	0.060	1	EURONERZ	83%	Eastern
3059	0.057	2	TALLIN	97%	Eastern	3247	0.060	1	EURONERZ	83%	Eastern
3060	0.057	2	TALLIN	97%	Eastern	3158	0.060	1	TALLIN	97%	Eastern
3061	0.057	2	TALLIN	97%	Eastern	3159	0.060	1	TALLIN	97%	Eastern
3100	0.057	2	EURONERZ	79%	Eastern	3111	0.060	2	EURONERZ	83%	Eastern
2535	0.057	7	EURONERZ	84%	Eastern	3257	0.060	0	EURONERZ	82%	Eastern
2522	0.057	7	EURONERZ	86%	Eastern	3258	0.060	0	EURONERZ	82%	Eastern
3047	0.058	2	TALLIN	95%	Eastern	3127	0.061	1	EURONERZ	84%	Eastern
2749	0.058	5	EURONERZ	83%	Eastern	3161	0.061	1	TALLIN	99%	Eastern
2750	0.058	5	EURONERZ	83%	Eastern	3162	0.061	1	TALLIN	99%	Eastern
2941	0.058	3	TALLIN	97%	Eastern	3163	0.061	1	TALLIN	99%	Eastern
2942	0.058	3	TALLIN	97%	Eastern	3164	0.061	1	TALLIN	99%	Eastern
2845	0.059	3	EURONERZ	80%	Eastern	3165	0.061	1	TALLIN	99%	Eastern
2667	0.059	5	TALLIN	97%	Eastern	3166	0.061	1	TALLIN	99%	Eastern
2737	0.059	5	EURONERZ	81%	Eastern	2943	0.061	3	TALLIN	97%	Eastern
3137	0.059	1	EURONERZ	82%	Eastern	3140	0.061	1	TALLIN	99%	Eastern
3001	0.060	3	EURONERZ	82%	Eastern	3141	0.061	1	TALLIN	99%	Eastern
2833	0.060	4	EURONERZ	83%	Eastern	3142	0.061	1	TALLIN	99%	Eastern
3246	0.060	1	EURONERZ	83%	Eastern	2940	0.061	3	HELSINKI	99%	Eastern
3157	0.060	1	TALLIN	97%	Eastern	3228	0.061	1	EURONERZ	82%	Eastern
3160	0.060	1	TALLIN	97%	Eastern	3229	0.061	1	EURONERZ	82%	Eastern

Males					
ID	MK	Age	Location	%known	Population
3156	0.060	1	ZOODYSSEE	97%	Eastern
3025	0.061	2	EURONERZ	82%	Eastern
3126	0.061	1	EURONERZ	84%	Eastern
2523	0.061	7	EURONERZ	86%	Eastern
2935	0.061	3	TALLIN	99%	Eastern
3138	0.061	1	TALLIN	99%	Eastern
3139	0.061	1	TALLIN	99%	Eastern
2936	0.061	3	ZOODYSSEE	99%	Eastern
3227	0.061	1	EURONERZ	82%	Eastern
3230	0.061	1	EURONERZ	82%	Eastern
2772	0.061	4	KERKRADE	82%	Eastern
3086	0.062	2	TALLIN	98%	Eastern
3152	0.062	1	TALLIN	97%	Eastern
3153	0.062	1	TALLIN	97%	Eastern
3154	0.062	1	TALLIN	97%	Eastern
3150	0.062	1	ZOODYSSEE	97%	Eastern
3151	0.062	1	ZOODYSSEE	97%	Eastern
2874	0.062	3	EURONERZ	81%	Eastern
3267	0.063	0	EURONERZ	82%	Eastern
3269	0.063	0	EURONERZ	82%	Eastern
3270	0.063	0	EURONERZ	82%	Eastern
3271	0.063	0	EURONERZ	82%	Eastern
3232	0.063	1	EURONERZ	83%	Eastern
3233	0.063	1	EURONERZ	83%	Eastern
3272	0.063	1	EURONERZ	83%	Eastern
2713	0.063	4	TALLIN	100%	Eastern
3285	0.075	1	FIEB	100%	Western
3286	0.075	1	ALAVA	100%	Western
3287	0.075	0	FIEB	100%	Western
3288	0.075	1	PONTSUERT	100%	Western
3179	0.080	7	PARQNATUR	100%	Western
3219	0.081	1	FIEB	100%	Western
2388	0.081	7	PONTSUERT	100%	Western
3279	0.083	0	ALAVA	100%	Western
3216	0.083	1	FIEB	100%	Western
3181	0.083	7	MADRID Z	100%	Western
3188	0.083	5	PONTSUERT	100%	Western
3217	0.083	1	FIEB	100%	Western
3200	0.084	3	ADEFFA	100%	Western
3207	0.085	3	FIEB	100%	Western
3208	0.085	3	MADRID Z	100%	Western
3276	0.085	1	FIEB	100%	Western
3278	0.085	1	FIEB	100%	Western
3222	0.085	2	PONTSUERT	100%	Western

Females					
ID	MK	Age	Location	%known	Population
3231	0.061	1	EURONERZ	82%	Eastern
3239	0.062	1	EURONERZ	82%	Eastern
3155	0.062	1	TALLIN	97%	Eastern
3110	0.062	2	EURONERZ	83%	Eastern
3125	0.062	1	EURONERZ	84%	Eastern
3248	0.062	1	EURONERZ	82%	Eastern
3266	0.063	0	EURONERZ	82%	Eastern
3268	0.063	0	EURONERZ	82%	Eastern
3234	0.063	1	EURONERZ	83%	Eastern
2937	0.064	3	TALLIN	99%	Eastern
2774	0.065	4	EURONERZ	82%	Eastern
2997	0.065	3	EURONERZ	84%	Eastern
3184	0.081	6	PONTSUERT	100%	Western
3284	0.083	1	ADEFFA	100%	Western
3280	0.083	0	FIEB	100%	Western
3281	0.083	0	FIEB	100%	Western
3282	0.083	1	FIEB	100%	Western
3283	0.083	1	FIEB	100%	Western
3215	0.083	1	FIEB	100%	Western
3187	0.083	5	JEREZ	100%	Western
3202	0.084	3	PONTSUERT	100%	Western
3210	0.085	3	ADEFFA	100%	Western
3277	0.085	1	FIEB	100%	Western
3190	0.085	5	ADEFFA	100%	Western
3220	0.085	2	PONTSUERT	100%	Western
3221	0.085	2	PONTSUERT	100%	Western
3201	0.085	3	FIEB	100%	Western
3204	0.086	3	ALAVA	100%	Western
3205	0.086	3	ALAVA	100%	Western
3199	0.086	3	PONTSUERT	100%	Western
3195	0.086	4	FIEB	100%	Western
3273	0.086	1	PONTSUERT	100%	Western
3274	0.086	1	PONTSUERT	100%	Western
3275	0.086	1	PONTSUERT	100%	Western
3203	0.086	3	ALAVA	100%	Western
3182	0.087	7	FIEB	100%	Western
3196	0.087	4	PONTSUERT	100%	Western

Males					
ID	MK	Age	Location	%known	Population
3223	0.085	2	PONTSUERT	100%	Western
3206	0.086	3	CORDOBA	100%	Western
3197	0.086	4	PONTSUERT	100%	Western

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Resources

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Appendix G
Effect of generations in captivity on litter size

It was suspected that the average litter size had changed in the European mink EEP population over time. The logic behind this is that offspring in large litters have a better chance of surviving in captivity than in the wild. Assuming that litter size is heritable, litter sizes would be expected to increase over time. Using the studbook data, it is possible to investigate the changes in litter size over time and over an increasing number of generations in captivity. Any results however, must be interpreted with caution because the data may be biased; historically relatively fewer individuals were recorded that died at an early age, which will bias the data towards smaller litter sizes further back in time.

The data do not show an increase or decrease in litter size in the EEP population since 1 January 2000, based on four intervals of four years with sample sizes of at least 115 reproducing dams. When looking at the data per decade, the average recorded litter size between 1980 and 1990 was only 1.6 kits (N= 70). This is much lower than the average recorded litter size of 3.3 kits between 1990 and 2000 (N= 143). The average litter size recorded since 2000 is 4.1 kits (N= 306). Part, or all of this seemingly changing litter size may be due to improvements in data recording.

A trend is also found when looking at the average litter size versus average generations since the wild caught founders for females in TALLIN zoo (Figure 12). However, individuals that are fewer generations away from the founder generation tend to have lived longer ago. Therefore, this data will still be biased if data in the past are less complete.

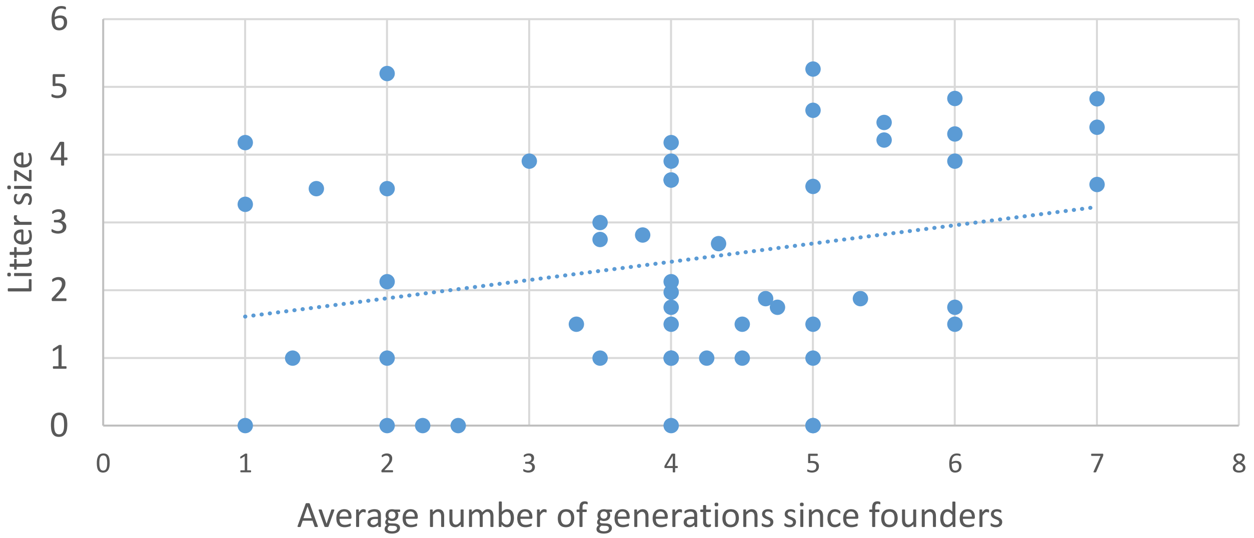

Figure 12. Litter size versus number of generations in captivity based on 53 female European mink that are recorded in the studbook between 1971 and 2016 and that have lived in TALLIN. The data are expected to be biased, with historically relatively fewer individuals recorded in the studbook that died at an early age and therefore creating a bias towards smaller litter sizes historically, when the population was on average fewer generations in captivity.

Appendix H
Definitions

Demographic Terms

Age Distribution – A two-way classification showing the numbers or percentages of individuals in various age and sex classes.

Ex, Life Expectancy – Average years of further life for an animal in age class x.

Lambda (λ) or Population Growth Rate – The proportional change in population size from one year to the next. Lambda can be based on life-table calculations (the expected lambda) or from observed changes in population size from year to year. A lambda of 1.11 means a 11% per year increase; lambda of .97 means a 3% decline in size per year.

lx, Age-Specific Survivorship – The probability that a new individual (e.g., age 0) is alive at the *beginning* of age *x*. Alternatively, the proportion of individuals which survive from birth to the beginning of a specific age class.
Mx, Fecundity – The average number of same-sexed young born to animals in that age class. Because SPARKS is typically using relatively small sample sizes, SPARKS calculates Mx as 1/2 the average number of young born to animals in that age class. This provides a somewhat less "noisy" estimate of Mx, though it does not allow for unusual sex ratios. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Px, Age-Specific Survival – The probability that an individual of age *x* survives one time period; is conditional on an individual being alive at the beginning of the time period. Alternatively, the proportion of individuals which survive from the beginning of one age class to the next.

Qx, Mortality – Probability that an individual of age *x* dies during time period. Qx = 1-Px

Risk (Qx or Mx) – The number of individuals that have lived during an age class. The number at risk is used to calculate Mx and Qx by dividing the number of births and deaths that occurred during an age class by the number of animals at risk of dying and reproducing during that age class.
The proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk").

Vx, **Reproductive Value** – The expected number of offspring produced this year and in future years by an animal of age

Genetic Terms

Allele Retention – The probability that a gene present in a founder individual exists in the living, descendant population.

Current Gene Diversity (GD) -- The proportional gene diversity (as a proportion of the source population) is the probability that two alleles from the same locus sampled at random from the population will not be identical by descent. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating, and if the population were in Hardy-Weinberg equilibrium.

Effective Population Size (Inbreeding N_e) -- The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in gene frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of gene frequency drift is measured in the current generation).

FOKE, First Order Kin Equivalents – The number of first-order kin (siblings or offspring) that would contain the number of copies of an individuals alleles (identical by descent) as are present in the captive-born population. Thus an offspring or sib contributes 1 to FOKE; each grand-offspring contributes 1/2 to FOKE; each cousin contributes 1/4 to FOKE. FOKE = 4*N*MK, in which N is the number of living animals in the captive population.

Founder – An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own descendants).

Founder Contribution -- Number of copies of a founder's genome that are present in the living descendants. Each offspring contributes 0.5, each grand-offspring contributes 0.25, etc.

Founder Genome Equivalents (FGE) – The number wild-caught individuals (founders) that would produce the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Genome Surviving – The sum of allelic retentions of the individual founders (i.e., the product of the mean allelic retention and the number of founders).

Founder Representation -- Proportion of the genes in the living, descendant population that are derived from that founder. I.e., proportional Founder Contribution.

GU, Genome Uniqueness – Probability that an allele sampled at random from an individual is not present, identical by descent, in any other living individual in the population. GU-all is the genome uniqueness relative to the entire population. GU-Desc is the genome uniqueness relative to the living non-founder, descendants.

Inbreeding Coefficient (F) -- Probability that the two alleles at a genetic locus are identical by descent from an ancestor common to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

Kinship Value (KV) – The weighted mean kinship of an animal, with the weights being the reproductive values of each of the kin. The mean kinship value of a population predicts the loss of gene diversity expected in the subsequent generation if all animals were to mate randomly and all were to produce the numbers of offspring expected for animals of their age.

Mean Generation Time (T) – The average time elapsing from reproduction in one generation to the time the next generation reproduces. Also, the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation times.

Mean Kinship (MK) – The mean kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

Percent Known – Percent of an animal's genome that is traceable to known Founders. Thus, if an animal has an UNK sire, the % Known = 50. If it has an UNK grandparent, % Known = 75.

Prob Lost – Probability that a random allele from the individual will be lost from the population in the next generation, because neither this individual nor any of its relatives pass on the allele to an offspring. Assumes that each individual will produce a number of future offspring equal to its reproductive value, Vx.

Appendix I

Directory of institutions keeping European mink

Mnemonic	Institution name	Country	Contact name	Email
ADEFFA	Associació de Defensa i Estudi de la Fauna i Flora Autòctona	Spain	Nuria Valls	a.adeffa@gmail.com
ALAVA	Private person	Spain	Anto Aguilar	anto.faunadealava@gmail.com
AHTARI	Zoo Ahtari	Finland	Mauno Seppäkoski	mauno.seppakoski@ahtarizoo.fi
BOJNICE	Zoologicka zahrada Bojnice	Slovakia	Branislav Tam	b.tam@zoobojnice.sk
CALVIAC	Reserve Zoologique de Calviac	France	Emmanuel Mouton	contact@reserve-calviac.org
CHOMUTOV	Zoopark Chomutov	Czech republic	Miroslav Brtnicky	zoolog@zoopark.cz
CORDOBA	Parque Zoologico de Cordoba	Spain		conservador.zoo@ayuncordoba.es
DECIN	Zoo Decin	Czech republic	Tomàš Rus	rus@zoodecin.cz
EURONERZ	Verein zur Erhaltung des Europäischen Nerzes-EuroNerz e.V.	Germany	Christian Seebass	christian.seebass@biologie.uni-osnabrueck.de
FIEB	FIEB Foundation	Spain	To Be Determined	To Be Determined
HELSINKI	Helsinki Zoo	Finland	Ville Vepsalainen	ville.vepsalainen@hel.fi
JEREZ	Zoobotánico Jerez	Spain	Iñigo Sanches Garcia	i.sanchez@aytojerez.es
KERKRADE	GaiaZoo, Kerkrade	Kerkrade	Tjerk ter Meulen	t.termeulen@gaiazoo.nl
LEDEC	Stanice Ochrony Fauny	Czech republic	Lenka Michalcikova	stanicepavlov@seznam.cz
MADRID Z	Zoo Aquarium de Madrid (GRPR)	Spain	Maria Delclaux	MDelClaux@grpr.com
PARQNATUR	Parque de la Naturaleza de Navarra	Spain	Lucia Hernandez	lhernandez@sendaviva.com
PONTSUERT	Centro de Fauna del Pont de Suert	Spain	Madis Podra	Madis.podra@yahoo.es
POZNAN	Ogrod Zoologiczny w Poznaniu	Poland	Maja Szymanska	m.szymanska@zoo.poznan.pl
RANUA	Ranua Wildlife Park	Finland	Mari Heikkilä	mari.heikkila@ranua.fi
RIGA	Riga Zoo	Latvia	Guna Vitola	guna.vitola@rigazoo.lv

Mnemonic	Institution name	Country	Contact name	Email
TALLIN	Tallinn Zoo	Estonia	Tiit Maran	tiit.maran@tallinnzoo.ee
TALLIN	Tallinn Zoo	Estonia	Kristel Nemvalts	kristel.nemvalts@tallinnzoo.ee
HANKENSBU	Otter Zentrum Hankensbuttel	Germany	Hans-Heindrich Krüger	h.krueger@otterzentrum.de
ZOODYSSEE	Zoodysée	France	Pierre-Jean Albaret	Pierre-Jean.ALBARET@cg79.fr