FIELD REPORT

2017

Monitoring of the Peregrine Falcon population in South Greenland

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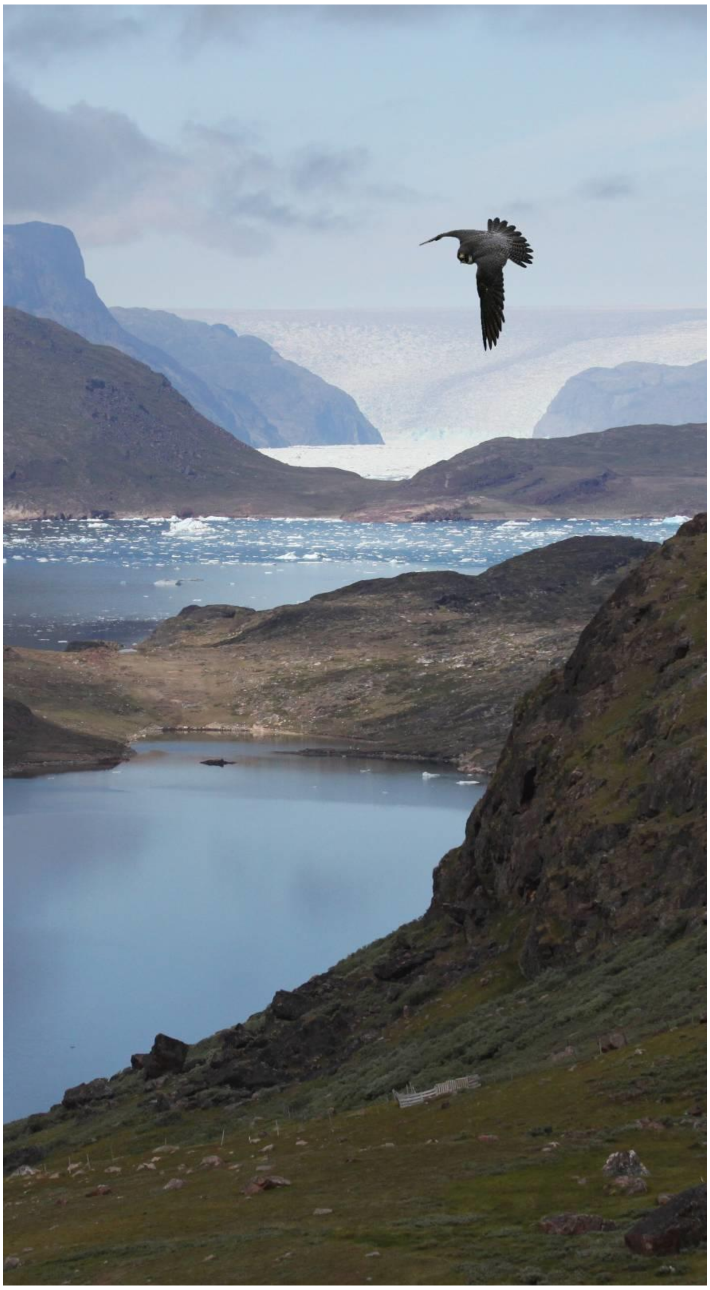
http://vandrefalk.dk/index_eng.shtml

Introduction

For several decades, the Peregrine Falcon has served as an indicator species for the environmental effects of pesticides and other contaminants. Since 1981 we have conducted annual investigations of various aspects of Peregrine (*Falco peregrinus tundrius*) ecology and contaminant loads in the breeding population in South Greenland, and results include:



- The identification of a slow, gradual decrease in classical pesticide loads and associated eggshell thinning effects.[1]
- Increased burdens of new contaminants such as brominated flame retardants.[2]
- The Peregrines in South Greenland maintain a high productivity – 2.9 young/ successful pair, or 1.9 young/occupied territory and 1.7 young/known territory (1981-2017). Over the past few years a worrying drop in productivity were observed, but by 2017 the trend is reversed. The high reproduction on average, so far, is to compensate for a high adult (female) turnover of around 25% (1985-2003).
- Breeding phenology is gradually shifting towards earlier hatching dates, possibly as a consequence of changing climatic conditions.
- Ring recoveries and Geolocator data (see below) reveal that the Peregrines migrate to Latin America – which is probably the source areas of the classical pesticides – whereas the more specific source areas of the new potentially harmful substances are more uncertain.

Research objectives

The overall project objective is to *monitor and assess current and future impacts of environmental changes – chemical as well as climatic – and their effects on the Peregrine Falcon population in Greenland*. Hence, we aim to continue one of the longest raptor monitoring efforts in the Arctic.

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[1] Falk *et al.* (2005), Vorkamp *et al.* (2009, 2014, 2017a)

[2] Vorkamp *et al.* (2005, 2017a, 2017b)

Methods and approaches

The project is designed as a "lean" field programme to be conducted annually by two persons in 21-30 days. Small dinghies/Zodiacs are used to navigate the fjords between camp sites, from where the field team hikes to the selected standard monitoring Peregrine sites spanning the coastal and inland areas (see map, right).

All field work is based on *basic* monitoring parameters sampled at selected sites every year in the core survey area and include:

- Nest success and productivity - 3 parameters: proportion of occupied sites producing young, number of young per occupied and successful site. Data are compared to "critical thresholds" (USFWS 2003).
- Breeding phenology: Date of first hatching in each nest – measured by standard aging catalogue and wing length[3] or egg weight/measurements.
- Samples
    - Addled eggs collected for contaminant analyses
    - Eggshell fragments from hatched eggs – for monitoring change in eggshell thickness as a proxy for DDT/DDE contamination[4]
    - Moulted feathers for mercury and other metals.[5]

The 2012 migration study applied miniature (1.9 g) archival light level data loggers[6] ("geolocators" – GLs) providing daily locations almost year-round. Although we did not tag new females since 2016, a few birds are still carrying GLs and can potentially provide additional data.

Since 2013 we also collect data on prey density by recording passerines on line transects along the hikes to/from Peregrine nesting sites. We identify all species and age (adult or fledgling) and count all birds within 50 m horizontal distance from the observer path. This is a rough method providing an index for comparing changes and inter-year variability.

In 2017 we also installed automatic cameras in 6 nests to monitor final breeding success and identify possible causes for failure.

Field work 2017

In 2017, field work was conducted in two periods: 6-13 June (the falcons' incubation period) and 3-24 July (early chick-rearing) by Knud Falk and Søren Møller assisted by Lena Hansson, Marianne Lind, Linnea Carlzon and Amanda Karlsson. In 2017 the weather was quite "average" with intermittent spells of rainy days and dry, sunny periods – i.e. normal conditions for the breeding falcons. A total of 18 site visits to the 12 core sites were conducted. Passerines were recorded at seven different line transects covering a total of 16.8 km in July, and 13.6 km in June.

The standard Peregrine Falcon sample sites selected for long-term monitoring in South Greenland

Field work is based on a boat-based two-three man team navigating the fjords and hiking to each of the cliffs included in the monitoring programme

Egg mass and measurements helps determine hatching dates

Addled eggs are collected for contaminant analyses along with any shell fragments from hatched eggs for monitoring eggshell thickness.

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[3] Clum *et al*. (1996), White *et al.* (2002)
[4] Falk *et al.* (2005)
[5] Dietz *et al*. (2006)
[6] http://birdtracker.co.uk/

Results

Occupancy

11 out of 12 monitoring sites were occupied by at least one defensive adult Peregrine, and 7 pairs (56%) were breeding – which is a recovery since the past few years with record lows (Fig. 2).

Breeding success

The productivity was back in the normal range after the overall low in 2016 (Fig. 1)

Figures 1 and 2 include the critical limits (red lines) as defined, based on literature reviews, in *Monitoring Plan for the American Peregrine Falcon* (USFWS 2003) and it is clear that the Peregrine in South Greenland in most years have favourable reproduction, but with two dips over the study period – fluctuations that only long-term monitoring can detect.

Breeding phenology

Mean hatching date for first egg in the 7 clutches determined was 1st July or 2 days earlier than the overall average (3 July) for 1981-2017. Over the study period, the overall average hatching date has moved from 4 to 3 July.

Samples

Eggshell fragments were collected at six of the successful sites (table 1). In addition, three dead whole eggs (2+1) were collected from two nests, and feathers were collected at three sites.

All samples were transferred to Denmark with veterinary and CITES permits as required.

Data review

After the 2016 field season, all data from 1981 onwards were revisited and stricter criteria for inclusion applied. The revision caused slight adjustments in the results shown in figures 1-4 which are replacing any previous presentation of results. The estimates of breeding success are based on full broods of any age, but in Figure 1 the yellow line represents success based only on broods where chicks reached at least 8 days of age – reducing the sample size considerably in some years. Some mortality occurs all the way through the nesting period, so success is slightly overestimated by both methods.

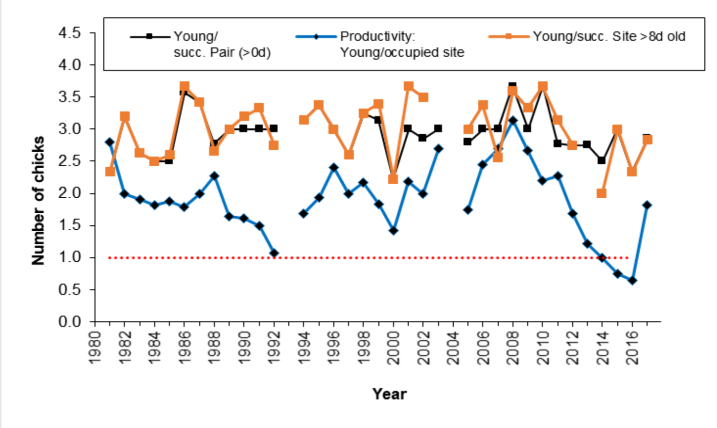

Figure 1: Annual production during the entire monitoring programme – measured as no of young/successful pair (full broods, young of any age, black line); young/successful pair (young reached at least 8 days of age, red line); no of young per occupied site ("productivity," blue line) – for all sites checked each year; the red line is the critical limit for productivity that "will initiate a special review" according to USFWS (2003).

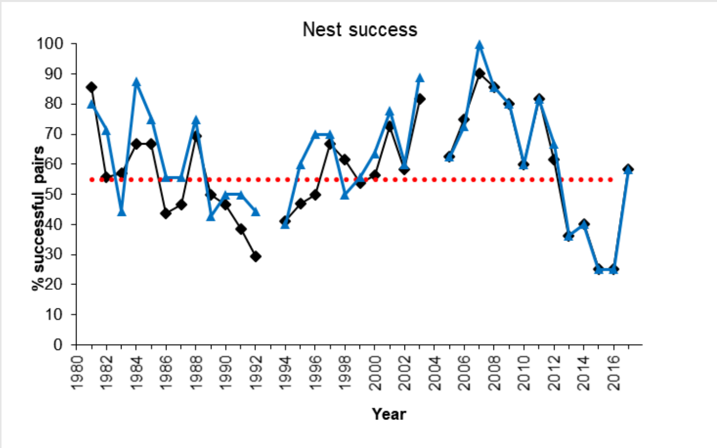

Figure 2: Nest success- proportion of occupied historical/"known" sites that produced young; black line is all sites, blue line is comparable "monitoring sites" only (smaller sample size 1981-2002). The red line is the threshold where there "would be cause for concern in the short term" (USFWS 2003).

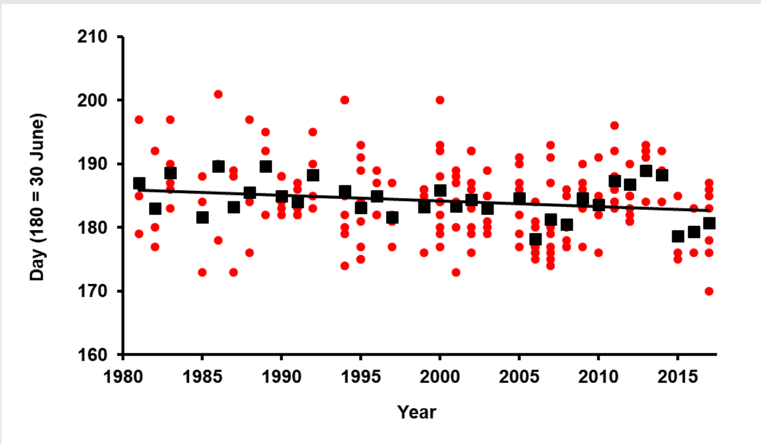

Figure 3: Hatching date for first egg in each clutch (red dots), mean hatch date per year (black squares) and the long-term trend (line) in breeding phenology over the study period (note: preliminary data only).

Monitoring of eggshell thickness
The thickness of eggshell fragments from the hatched eggs have been measured and added to the long-term trend analysis (based on Falk *et al.* 2006), showing the continued improvement in shell thickness (Fig. 4) although it is yet not back to normal. A more comprehensive reanalysis is now available.[7]

Migration studies by geolocators
In 2012, -13, -14 and -15, geolocators (GL) were deployed at a total of eleven different adult breeding females. Until 2015, GLs from three birds had been recovered for analysis of movements in the autumn/winter/springs of 2012-15. Data from the three GL's are plotted in Fig 5. Around equinox conversion of raw GL data to latitude information is not possible so data from this period has been omitted. However, longitude information around equinox remains reliable and can be used to extract some information on migration timing and route along the E-W direction.

All females were stationary at their wintering locations. The female from site 23 wintered on Hispaniola (Dominican Republic) after having started southward migration on October 1, 2012 and passing over Cuba around October 15. Spring migration started April 1 when it moved to NW Florida and remained stationary at least until the GL stopped working on April 18. The female from site 32 started southward migration around September 20, 2012 and arrived in Nicaragua/Costa Rica around October 20. It remained stationary until northbound migration started early April. The longitude data suggests it followed the east coast of the Gulf of Mexico, at least until the GL stopped collecting data on May 8. The female from site 1 wintered around Caracas, Venezuela, mid-October 2014 to early April and was back at the breeding site approx. 7 May.

In 2016 we recovered an additional GL from the female at site 32. It contained data from two cycles (2014-15 and 2015-16) indicating that this bird wintered in the same area as in 2012-13 and had nearly the same timing all years. At least two female peregrines from the study area still wear GLs and, if still alive, may be recaptured in 2018.

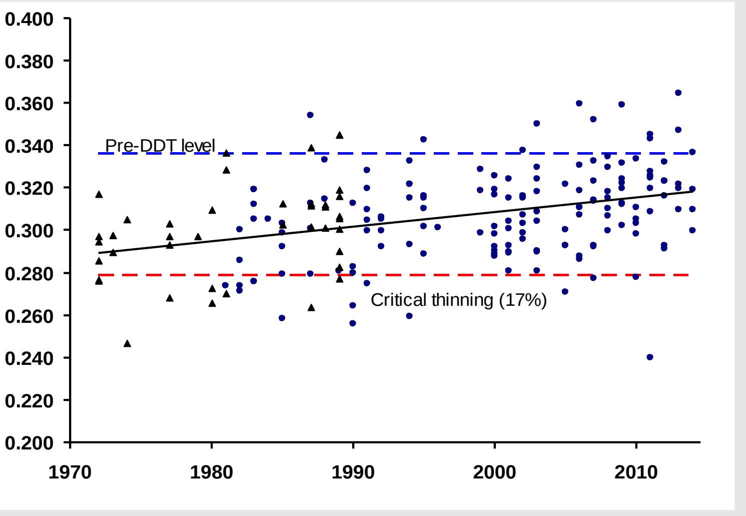

Figure 4: Eggshell thickness (incl. shell membranes) of fragments from hatched eggs in South Greenland 1981-2014 (circles) and central West Greenland 1972-1988 (triangles) as well as the joint trend line. Samples from 2015-17 have not been measured yet. The blue horizontal line indicates the average shell thickness in Greenlandic Peregrines before 1947 (= "normal" thickness) while the red line shows the 17% thinning threshold below which Peregrine populations have been shown to decline.[8]

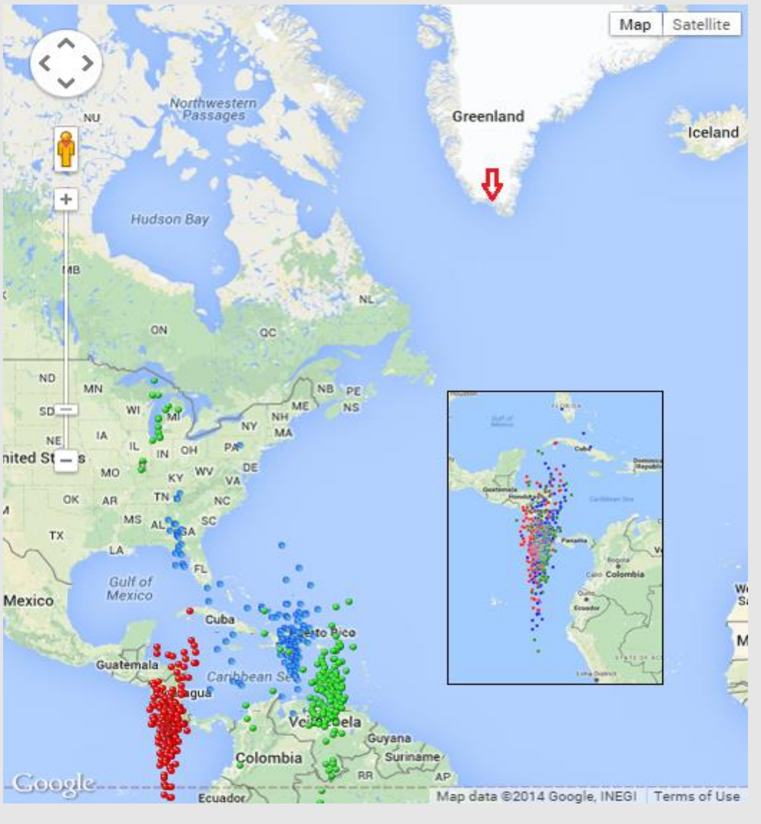

Figure 5: Geolocator data from three female peregrines from the study area (red arrow) in South Greenland. Blue dots: female breeding at site # 23 (2012-13), red: female breeding at site # 32 (2012-13), green: female breeding at site # 1 (2014-15). Data around equinox omitted; note that location uncertainty on latitude is several times larger than uncertainty on longitude.

Inset: Female at site #32, November – February; red dots: 2012-13, blue: 2014-15, green: 2015-16.

See text for further explanation *(Google maps screen dump)*.

[7] Vorkamp et al. (2017a)
[8] Falk & Møller (1990), Peakall & Kiff (1988)

Prey abundance
A total of 307 passerines were recorded during the 16.8 km line transects conducted 8 – 17 July. This translates into 18.2 birds/km transect; however, one transect with particular high activity of Redpolls (risk of duplicate observations) may have inflated the total (blue bar in Fig. 5). As usual, the most abundant species was the Wheatear, which had large broods of fledglings everywhere we went.

In 2014-17 the density of passerines was more than a factor 4 to 8 higher than in 2013, confirming that 2013 was probably a very unusual year, as we subjectively noted then.

In 2016 and 2017, the proportion of young birds appeared higher than the previous years.

Supplementary surveys conducted in early June 2017 ('2017-early' in Fig. 5) showed high passerine densities at this time of the year, i.e. when the breeding pairs are established, nests built and eggs laid, so all adults passerines are active – and available as prey to the Peregrines.

Monitoring data application

Circumpolar falcon monitoring
The Conservation of Arctic Flora and Fauna (CAFF) programme under Arctic Council has initiated the Circumpolar Biodiversity Monitoring Programme (CBMP) and is preparing *State of the Arctic Terrestrial Biodiversity Reports* for 2018-19. The Arctic falcons are key top predators included in the terrestrial monitoring plan[9] and we have helped establish an *Arctic Falcons Specialist Group* (AFSG) to facilitate cross-comparison of monitoring data from the circumpolar Arctic and try to harmonise basic sample protocols for future population monitoring. Currently, the first overview of long-term trends in the different sub-populations is being complied and analysed, including our data from South Greenland.

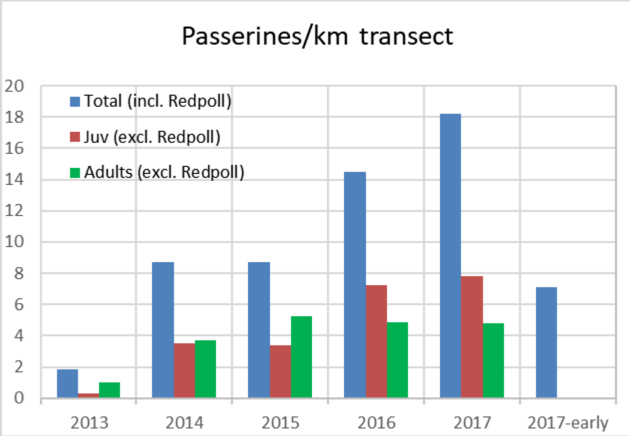

Figure 5: Relative density of passerines – main prey items – the past four year; observation conditions rarely allow aging of Redpolls which are excluded in the juv/adult bars

Passerines are the main prey of Peregrines in the study area where feathers of young, newly fledged Wheatears, Lapland Buntings and Redpolls are found on all successful Peregrine nesting ledges.

Passerines were about equally abundant in 2014 and 2015 but higher in 2016 and 2017; fledged Wheatear broods of up to 5 chicks were the most widespread and conspicuous on all transects surveyed in 2014-17.

[9] http://www.caff.is/monitoring-series/256-arctic-terrestrial-biodiversity-monitoring-plan

Table 1. Site checks of the core 'monitoring sites in 2017.

Site no.	Date	No of eggs	No of young	Hatching (1. chick)	Notes	Samples
1	10 + 11 Jun	0	0		1 adult	
2	12 Jun, 24 Jul	0	0		1 adult	
6	7 Jul	0	3	28 Jun	2 adults; camera installed	Eggshell fragments + feathers
7	10 + 21 Jul	1	3	3 Jul	2 adults; camera installed	Eggshell fragments, 1 dead egg
8	9 + 20 Jul		3	26 Jun	Huge cliff: no nest visit - young aged by telescope	
23	7 Jun + 6 + 19 Jul	2	2		2 adults; camera installed	Eggshell fragments, 1 dead egg, feathers
29	9 Jun + 22 Jul	0	0		2 adults, no breeding	
32	8 Jul	0	3		1 adult, no breeding	
42	12 Jul	0	4	6 Jul	2 adults; camera installed	Eggshell fragments + feathers
61	17 Jul	0	3	20 Jun	2 adults, female w/ GL. Earliest hatch ever recorded; camera installed	
63	8 Jun + 14 + 22 Jul	0	2	7 Jul	2 adults; camera installed	
66	8 Jun	0	0		No peregrines observed	

Acknowledgements

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Literature Cited

Clum, N., Harrity, P. & Weck, H. 1996. Aging young Peregrines. Pp 37-63 in Cade,T.J., Enderson, J.H. & Linthicum,J. (eds): Guide to Management of Peregrine Falcons at the Eyrie. The Peregrine Fund.

Dietz, R., Rigét, F.F., Boertmann, D., Sonne, C., Olsen, M.T., Fjeldså, J. Falk, K., Kirkegaard, M., Egevang, C., Asmund, G., Wille, F., Møller, S. 2006: Time trends of mercury in feathers of West Greenland birds of prey during 1851-2003. Environmental Science & Technology 40, 5911-5916.

Falk, K. & S. Møller 1990. Clutch size effects on eggshell thickness in the Peregrine Falcon and European Kestrel. Ornis Scand. 21:265-269

Falk, K. & Møller, S. & Mattox, WG. 2005. A long-term increase in eggshell thickness of Greenlandic Peregrine Falcons *Falco peregrinus tundrius*. Science of the Total Environment, 355(1-3), 127-134.

Peakall, D.B & Kiff, L.F. 1988. DDE contamination in Peregrines and American Kestrels and its effects on reproduction. Pp 337-350 in: Cade, T.J., J.H. Enderson, C.G. Thelander & C.M. White (eds.) 1988. Peregrine falcon populations: Their management and recovery. - Proc. 1985 Peregrine Conf., Sacramento, The Peregrine Fund, Boise, Idaho.

USFWS 2003. Monitoring Plan for the American Peregrine Falcon, A Species Recovered Under the Endangered Species Act. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Pacific Region, Portland, OR. 53 pp.

Vorkamp, K., Falk, F., Møller, S., Rigét, F.F., Bossi, R. & Sørensen, P.B. 2017a. New and updated time trends of persistent organic pollutants and their effects on eggs of peregrine falcons (Falco peregrinus) from South Greenland. Aarhus University, DCE – Danish Centre for Environment and Energy, 80 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 249 http://dce2.au.dk/pub/SR249.pdf

Vorkamp K, Falk K, Møller S, Rigét F, Sørensen P (2017b). Regulated and unregulated halogenated flame retardants in peregrine falcon eggs from Greenland. Environmental Science & Technology. DOI: 10.1021/acs.est.7b04866

Vorkamp, K., Møller, S. Falk, K., Rigét, F.F. Thomsen, M., Sørensen. P.B. 2014. Levels and trends of toxaphene and chlordane-related pesticides in peregrine falcon eggs from South Greenland. Science of the Total Environment. 2014, 468-469, 614-621.

Vorkamp, K., Thomsen, M., Falk, K., Leslie, H., Møller, S. & Sørensen, P.B. 2005: Temporal development of brominated flame retardants in peregrine falcon (*Falco peregrinus*) eggs from Southern Greenland (1986-2003). Environmental Science & Technology 39 (21), 8199-8206.

Vorkamp, K., Thomsen, M., Møller, S., Falk, K., Sørensen, P.B. 2009: Persistent organochlorine compounds in peregrine falcon (*Falco peregrinus*) eggs from South Greenland: Levels and temporal changes between 1986 and 2003. Environment International 35, 336-341.

White,C.M., Clum, N.J., Cade,T.C. & Hunt,W.G. 2002. Peregrine Falcon. The Birds of North America, No. 660.

Additional peer-reviewed publications from the project

Vorkamp, K., Thomsen, M., Falk, K., Leslie, H., Møller, S. & Sørensen, P.B. 2005: Temporal development of brominated flame retardants in peregrine falcon (*Falco peregrinus*) eggs from Southern Greenland (1986-2003). Environmental Science & Technology 39 (21), 8199-8206.

Sørensen, P.B., K. Vorkamp, M. Thomsen, K. Falk and S. Møller. Persistent organic pollutants (POPs) in the Greenland environment - Long-term temporal changes and effects on eggs of a bird of prey. National Environmental Research Institute, Denmark. 126 pp. NERI Technical report no. 509, 2004.

Dietz, R., F. Rigét, M.T. Olsen, C. Sonne, E. Born, P. Grandjean, M. Kirkegaard, G. Asmund, H. Baagøe, D. Boertman, K. Falk, J. Fjeldsaa, C. Egevang, F. Wille and S. Møller. The temporal and geographical mercury patterns in polar bears and birds of prey. - In: H. Skov, J. Christensen, G. Asmund, S. Rysgaard, T. Gissel Nielsen, R. Dietz and F. Riget. Fate of mercury in the Arctic (FOMA). National Environmental Research Institute, Denmark. 56 pp. NERI Technical report no. 511, 2004. p. 33-41.

Falk, K. & S. Møller 1988. Status of the peregrine falcon *Falco peregrinus* in South Greenland: Population density and reproduction. - I: Cade, T.J., J.H. Enderson, C.G. Thelander & C.M. White (eds.) 1988. Peregrine falcon populations: Their management and recovery. - Proc. 1985 Peregrine Conf., Sacramento, The Peregrine Fund, Boise, Idaho.

Falk, K. & S. Møller 1990. Clutch size effects on eggshell thickness in the Peregrine Falcon and European Kestrel. - Ornis Scand. 21:265-269.

Falk, K., S. Møller & W.A. Burnham 1986. The peregrine falcon *Falco peregrinus* in South Greenland: Nesting requirements, phenology and prey selection. - Dansk Orn. Foren. Tidsskr. 80:113-120.

Annex I: Ringing 2017

Ring no.	Site	Date	Type[1]	Sex[2]	Age	Unit[3]
3050466	61061	2017-07-17	M	F	27	D
3050470	61061	2017-07-17	M	F	27	D
3R-0404	61063	2017-07-22	M	F	15	D
3R-0405	61063	2017-07-22	M	F	15	D
4298331	61063	2017-07-22	M	M	14	D

1: O = observation of ringed adult; K=control; M = ringing
2: M = Male; F = Female
3: K = calendar year, D = days

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