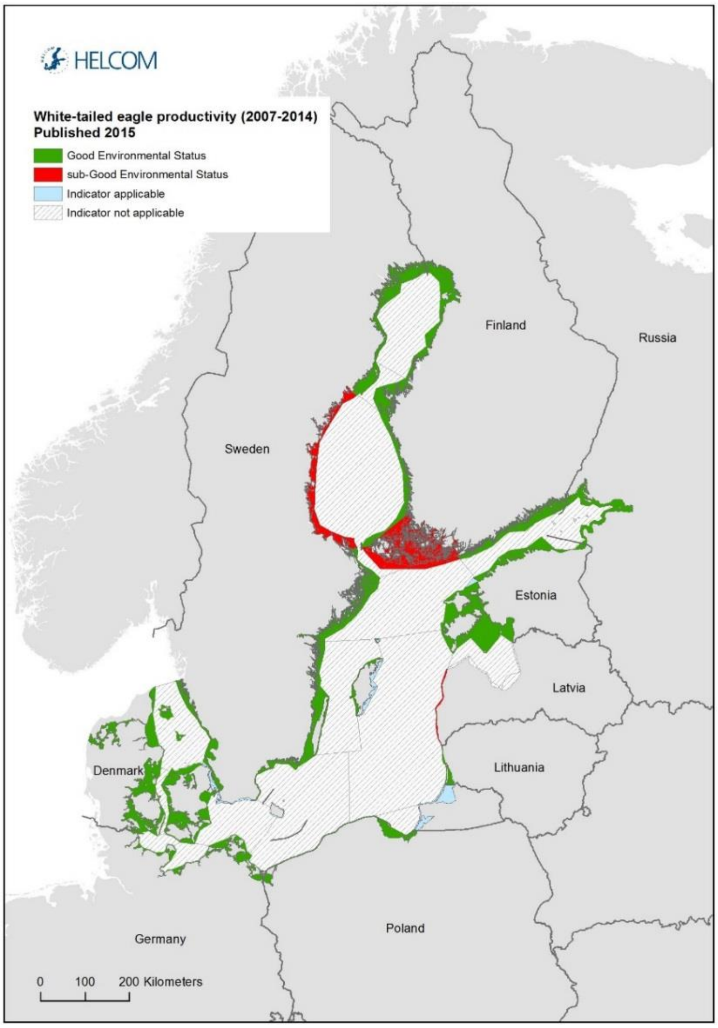
HELCOM core indicator report
January 2016

White-tailed eagle productivity

Key Message

This core indicator assesses the status of reproduction of white-tailed eagles by evaluating the parameter 'productivity' and the two supporting parameters 'brood size' and 'breeding success'. Good Environmental Status (GES) is achieved when all three parameters in an assessment unit have GES. The status of determined based on acceptable deviation of the parameters from a target level determined during a reference period. The status of white-tailed eagle productivity has been assessed for the period 2007-2014 (2012-2014 for Polish areas).



Key message figure 1: Status assessment results based on evaluation of the indicator 'white-tailed eagle productivity'. The assessment is carried out using Scale 3 HELCOM assessment units (for more information see the [HELCOM Monitoring and Assessment Strategy Annex 4](). Click to enlarge.

The productivity of white-tailed eagles achieved, or was is at least very close to, GES in all the coastal areas of the Baltic Sea. The sub-GES result for the Swedish coast of the Bothnia Sea and the Latvian coast is due to the nestling brood size parameter not reaching GES. The significantly higher occurrence of dead eggs in the Swedish part of the Bothnian Sea compared to other areas might indicate a higher impact from hazardous substances. The sub-GES result for the Archipelago Sea is due to the percentage of breeding success being slightly below the GES boundary. It should be noted that no white-tailed eagles breed in the innermost part of the Gulf of Riga.

The confidence of the indicator status evaluation is considered to be high.

The indicator is applicable in the coastal waters of all the countries bordering the Baltic Sea.

Relevance of the core indicator

As predators at the top-end of the aquatic food chain, white-tailed eagles are highly exposed to hazardous substances that accumulate and magnify through the food web and can thus serve as sentinels for effects of harmful substances. The elevated concentrations of persistent chemicals in white-tailed eagles also give possibilities to detect new emerging pollutants that are below detection limits in other biota.

The white-tailed eagle was the first species to signal the effects of persistent chemicals in the Baltic Sea environment already during the 1950s when its population was reduced to one fifth of the pre-1950 background level in the 1970s due to contamination from hazardous substances. The detection of PCB in Baltic white-tailed eagles occurred in 1966. After measures were implemented to ban the use of DDT and PCB, the reproductive success began improving after a delay of approximately a decade. The productivity reached that of a reference level by the mid-1990s, clearly exemplifying a case where the effects of environmental management actions are reflected in an improved environmental status.

Policy relevance of the core indicator

	BSAP segment and objectives	**MSFD Descriptor and criteria**
Primary link	Biodiversity • Healthy wildlife Hazardous substances • Concentrations of hazardous substances close to natural levels	D8. Contaminants 8 2. Effects of contaminants
Secondary link	Biodiversity: • Thriving and balanced communities of plants and animals • Viable populations of species	D1. Biodiversity 1.3. Population condition (fecundity rates) 1.1.Species distribution (range, pattern, covered area) 1.2. Population size (abundance) D4. Food webs 4.1. Productivity of key species or trophic groups (productivity) 4.3. Abundance/ distribution of key trophic groups and species
Other relevant legislation: In some Contracting Parties also: • EU Birds Directive. Listed in Annex I (species to be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution) • Water Frame Directive: Chemical quality • Washington Convention (CITES): listed in Appendix I (trade in specimens of these species is permitted only in exceptional circumstances).		

- Bonn Convention: listed in Appendix I (endangered migratory species) and Appendix II (migratory species to be the subject of agreements)
- Bern Convention: listed in Appendix II (strictly protected species).

Cite this indicator

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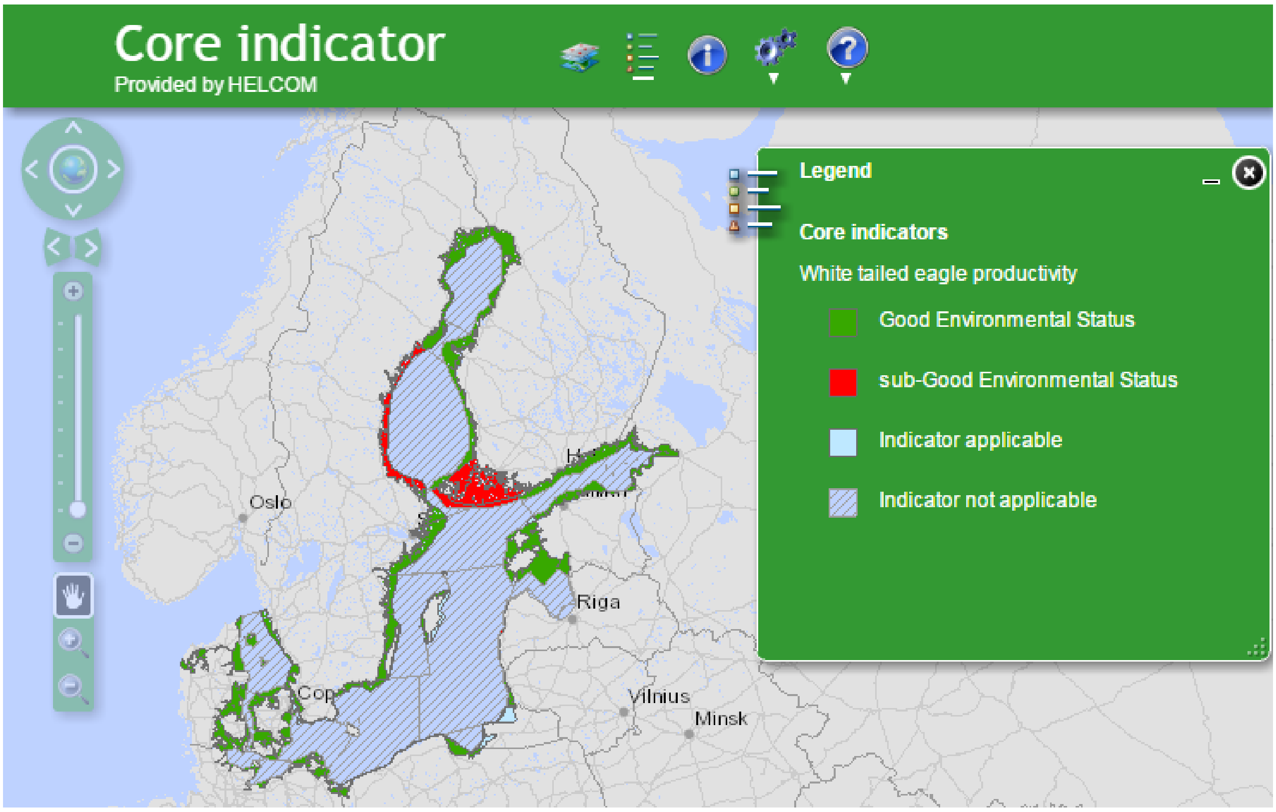
Core indicator report – web-based version January 2016 (pdf)

Extended core indicator report – outcome of CORESET II project (pdf)

Results and Confidence

The environmental state evaluation for the coastal areas of the Baltic Sea using productivity of white-tailed eagle considers three parameters: productivity, nestling brood size and breeding success. For the majority of the HELCOM assessment units, good environmental status (GES) is achieved for all three parameters in the evaluated period 2007-2014. The sub-GES status in the Swedish Bothnian Sea coastal area and the Latvian coast is due to the nestling brood size being too low, and in the Finnish Archipelago Sea due to breeding success being too low (Results figure 1).

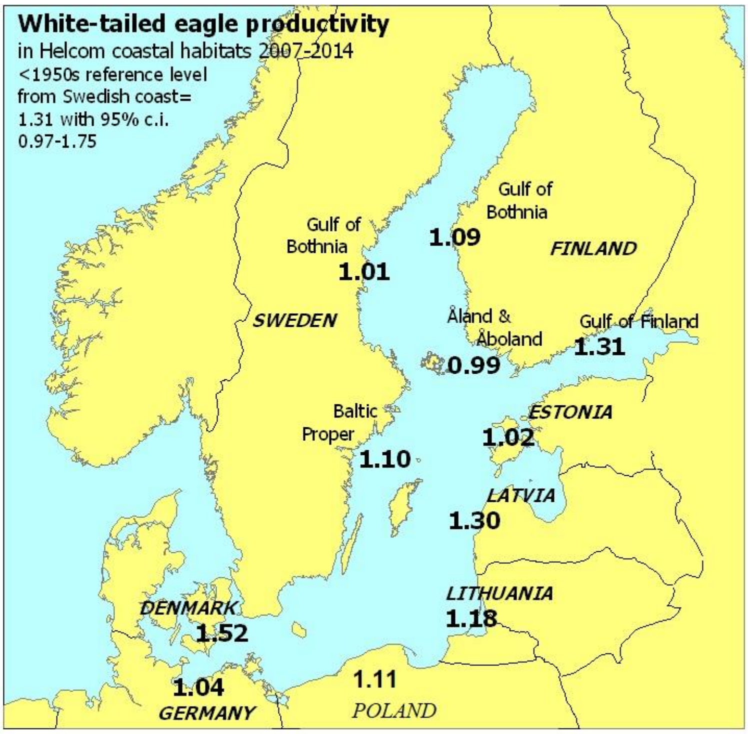


Results figure 1. The environmental status evaluation using white-tailed eagle productivity indicates that GES is achieved in most coastal areas for the period 2007-2014.

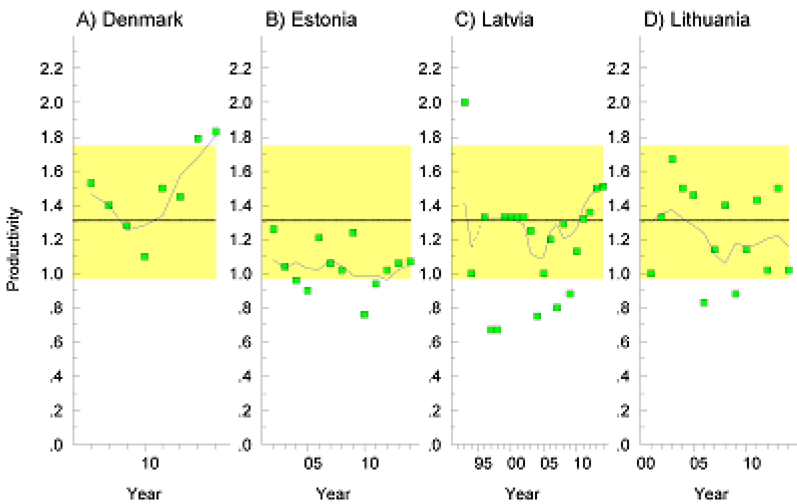
Productivity

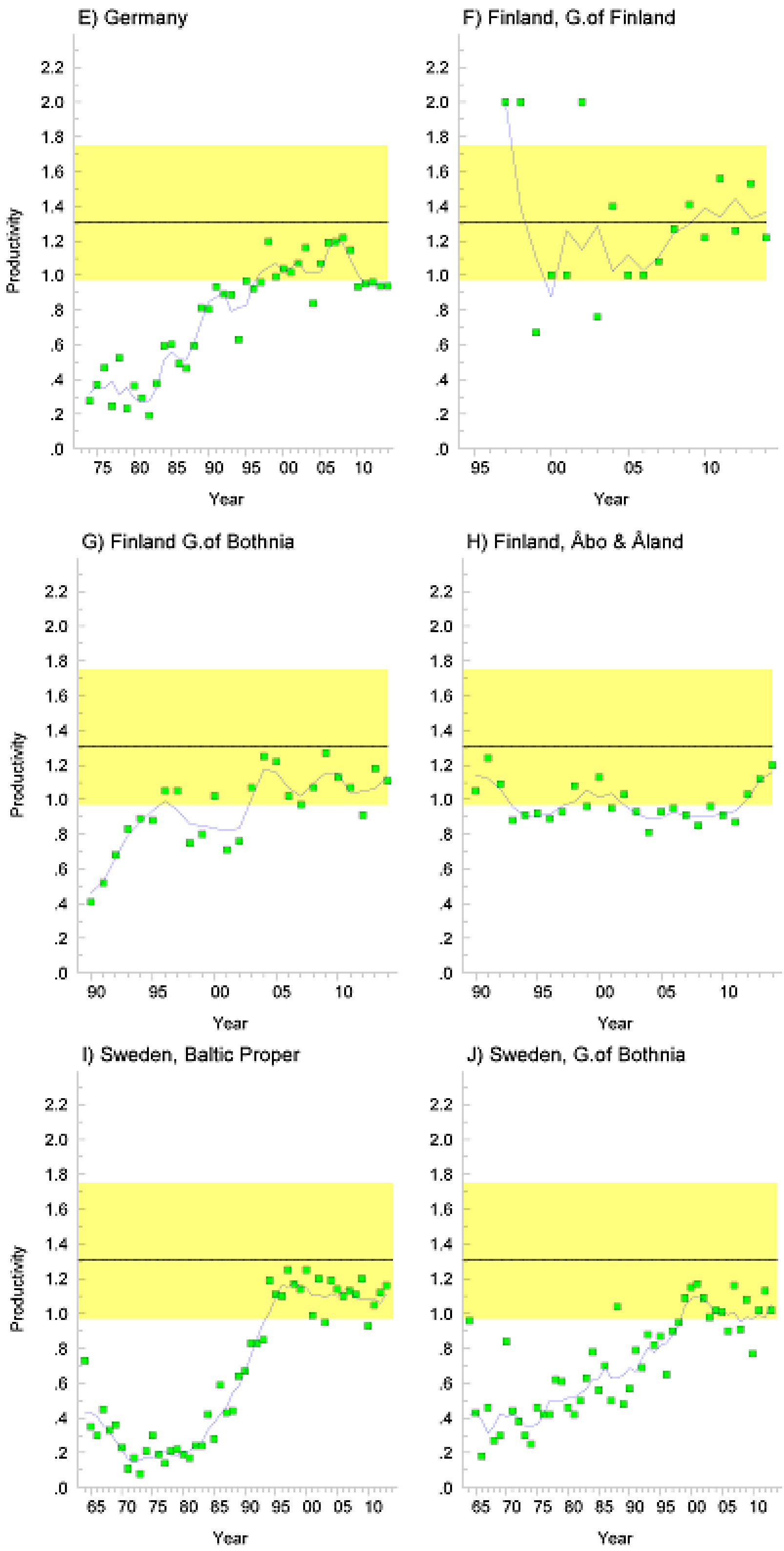
The evaluation of mean annual productivity during 2007-2014 indicates that GES is achieved in all studied areas (Results figure 2 and Results figure 3).

The time series since the 1970s, available for some countries, indicate a great increase in productivity as well as for nestling brood size and breeding success since the mid-1980s, and GES was reached or nearly reached for all three parameters mainly during the last 10 years. In some of the studied areas the increase in productivity has stabilized at the lower end of the estimated reference level, possibly as an effect of density-dependent competition for nest sites, as has been observed in Germany (Results figure 2 and Results figure 3).



Results figure 2. The status of productivity of the white-tailed eagle during 2007-2014 in the Baltic Sea (10 km coastal zone around the sea). The productivity score indicates the number of nestlings per checked territorial pair in the population (8-year average). Germany is represented by data from Mecklenburg- Western Pomerania. Polish data cover the years 2012-2014.

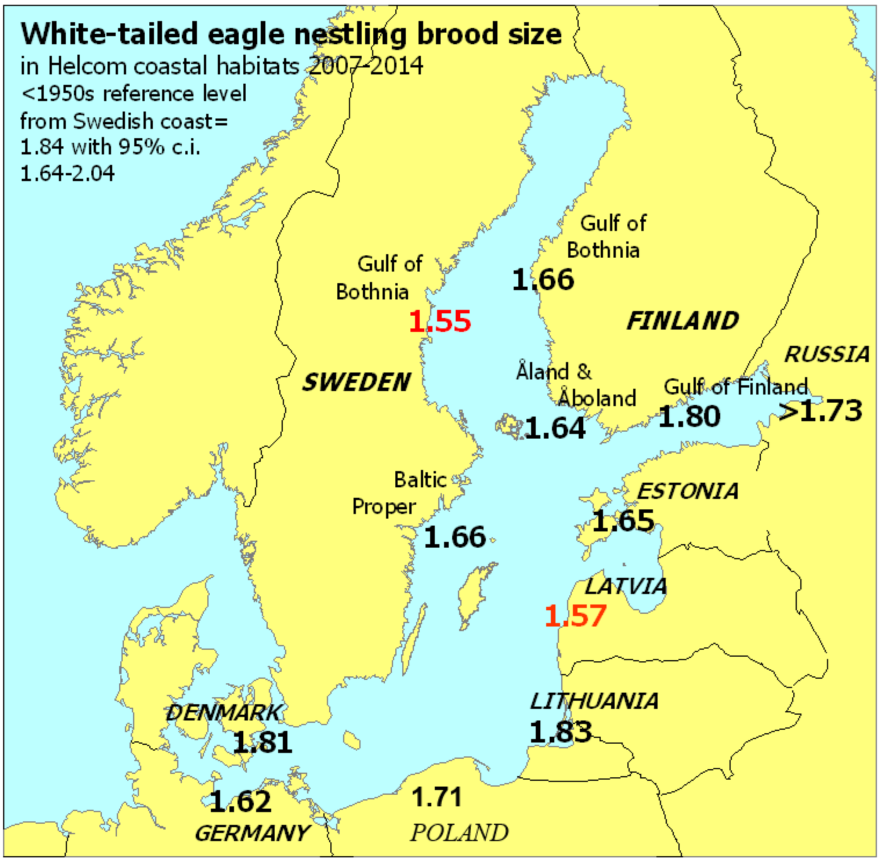




Results figure 3. Mean annual productivity (number of nestlings per checked occupied territory) of coastal subpopulations of white-tailed eagles around the Baltic Sea. The blue line in the graphs represents a locally weighted scatterplot smoothing (LOESS). A pre-1950 reference level (black line) with 95% confidence limits (yellow area) for breeding success (according to Helander 2003a) is given in each graph. Germany is represented by data from Mecklenburg- Western Pomerania.

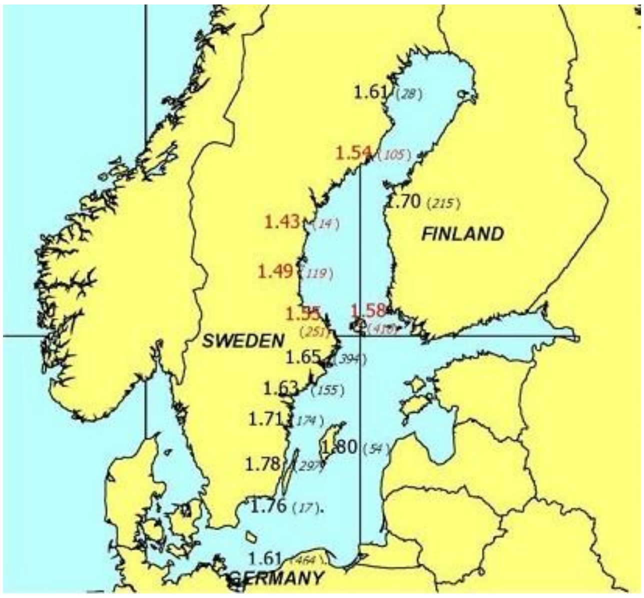
Nestling brood size

As illustrated in Results figure 4 and Results figure 7, nestling brood size reached, or is very close to reaching, GES in 2007-2014 in all coastal areas of the Baltic Sea. Nestling brood size did not achieve GES at the Swedish coast of the Bothnia Sea or the coastal area of Latvia (Results figure 4), although the scores were quite close to the target.



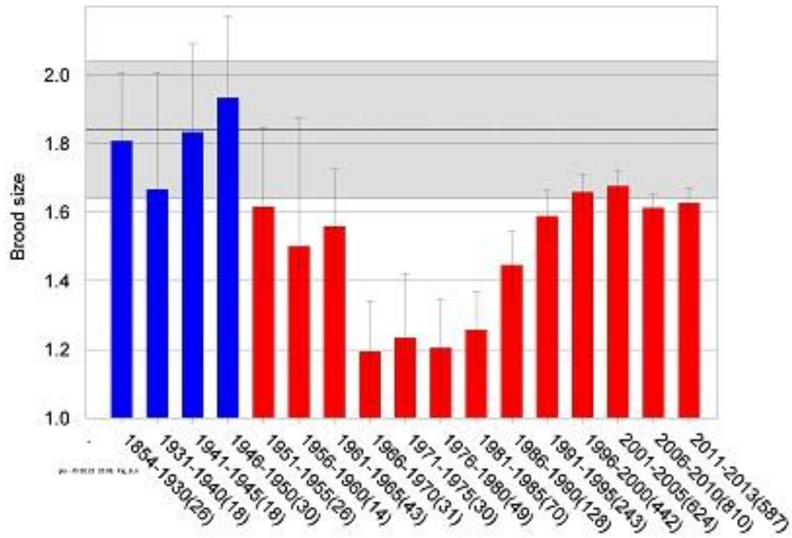
Results figure 4. The status of nestling brood sizes of the white-tailed eagle during 2007-2014 in the Baltic Sea (10 km coastal zone around the sea). The nestling brood size score indicates the number of nestlings per checked reproducing pair (8-year average for climbed nests). Red colour indicates score below the target for good environmental status (GES). Germany is represented by data from Mecklenburg-Western Pomerania. Polish data cover the years 2012-2014.

The smaller average nestling brood size on the Swedish coast of the Bothnian Sea during 2000-2009 is due to a significantly higher frequency of nests with young that also contained dead eggs: 7.1% as compared to 2.9% in the Baltic Proper (n = 461 and 932, respectively) (Results figure 5). This may imply an influence of hazardous substances on the hatching success in the Gulf of Bothnia. This case also indicates that nestling brood size is a more sensitive indicator, specifically for hazardous substances, than productivity.

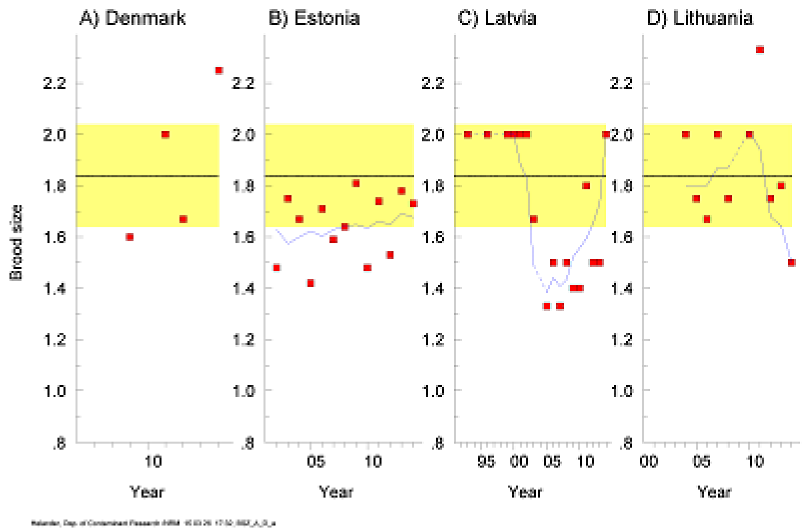


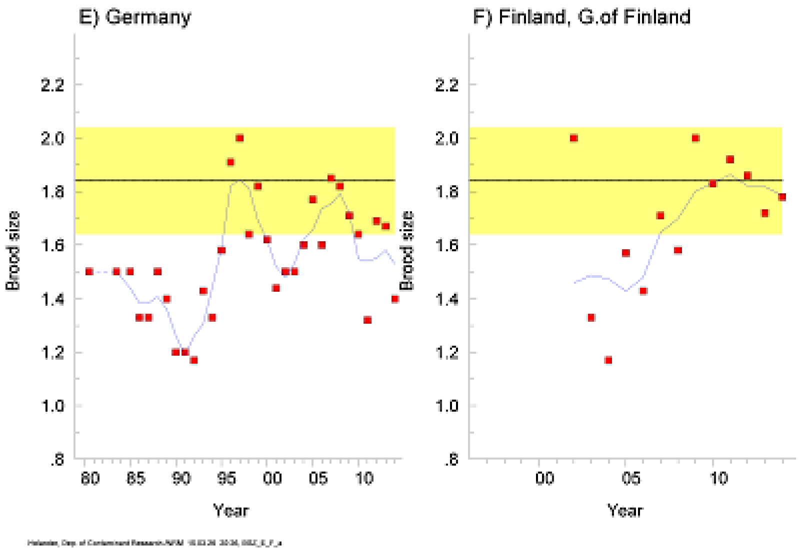
Results figure 5. Mean white-tailed sea eagle nestling brood size in sub-areas around the Baltic Sea in 2000–2010. Sample sizes are given in brackets. Nestling brood sizes below 1.60 are indicated in red. Data from Finland are from Stjernberg et al. 2003. Germany is represented by data from Mecklenburg- Western Pomerania.

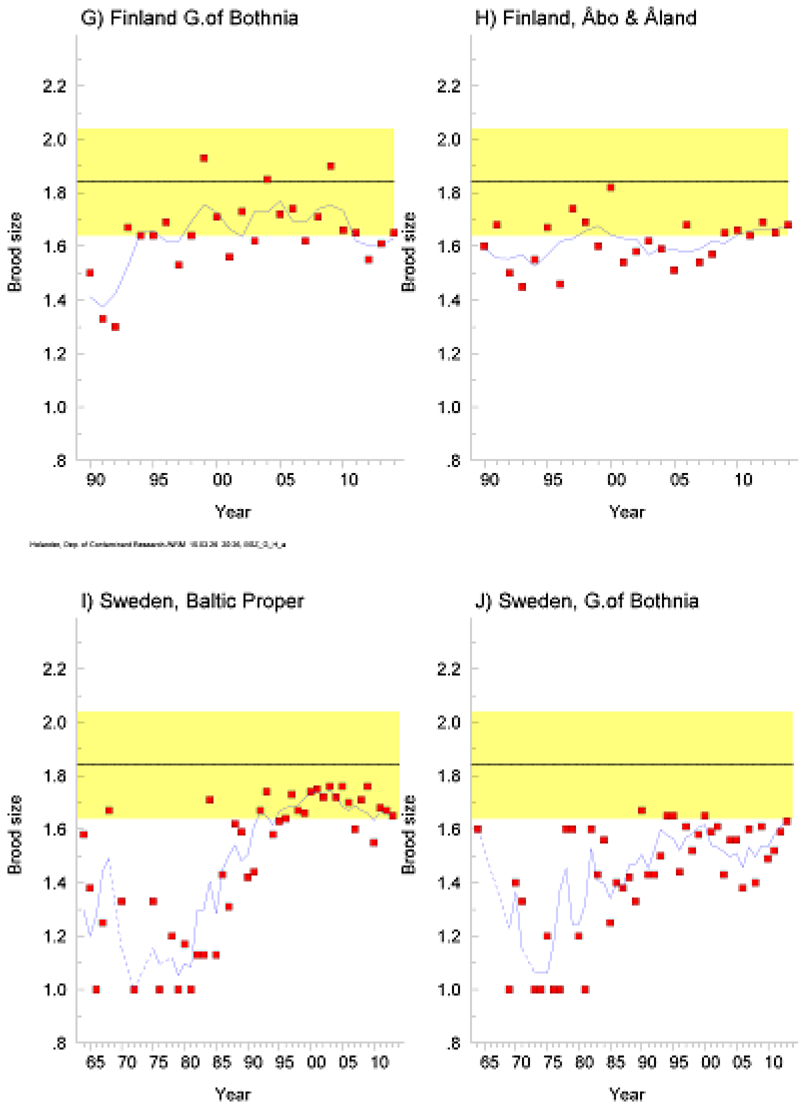
Nestling brood size has improved strongly since the 1970s but has still not reached GES in all parts of the Baltic Sea. Brood sizes began increasing in the studied areas from the 1980s (Result figure 6), roughly in synchrony with the increase in breeding success (Result figure 9). This is inherent with an improvement in the hatching success of the eggs, affecting both indicator parameters in parallel. Brood size in the Baltic Proper reached the lower end of the pre-1950 reference level in the late 1990s (Results figure 7). The huge fluctuations that show in some of the graphs in Figure 9 can be an artefact of small and varying sample sizes of climbed nests.



Results figure 6. Mean brood size (number of nestlings per successfully breeding pair) of white-tailed sea eagle on the Swedish Baltic Sea coast 1854-2013. Sample size for each time period is given in brackets. A reference level (solid black line) with 95% confidence limits (grey area) is based on data from 1854-1950 (blue bars) according to Helander (2003a).



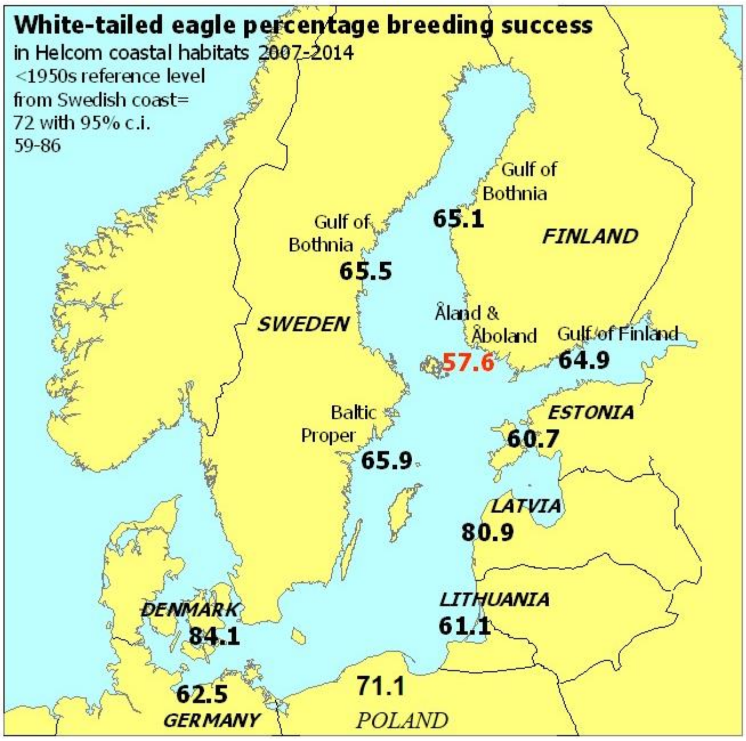




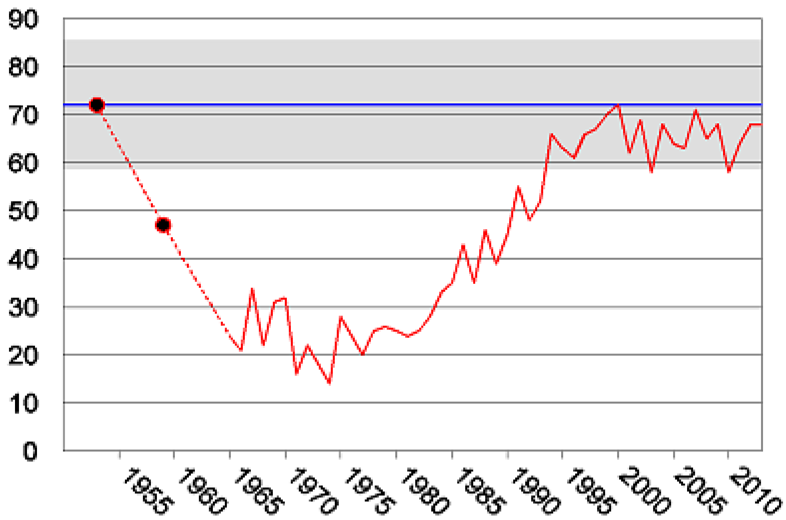
Results figure 7. Mean brood size (number of nestlings per successfully breeding pair) of coastal white-tailed sea eagle subpopulations around the Baltic Sea. The blue line in graphs represents a locally weighted scatterplot smoothing (LOESS). A pre-1950 reference level (black line) with 95% confidence limits (yellow area) according to Helander (2003a) is given in each graph. Germany is represented by data from Mecklenburg- Western Pomerania.

Breeding success

The breeding success of white-tailed eagles reached GES in nearly all areas along the Baltic Sea during 2007-2014 (Results figure 8). Retrospective studies have shown that breeding success along the whole Swedish Baltic Sea coast decreased from an average of 72% in the early 1950s, down to 47% between 1954–1963, and 22% between 1966-1982 (Results figure 9) (Helander 1985).

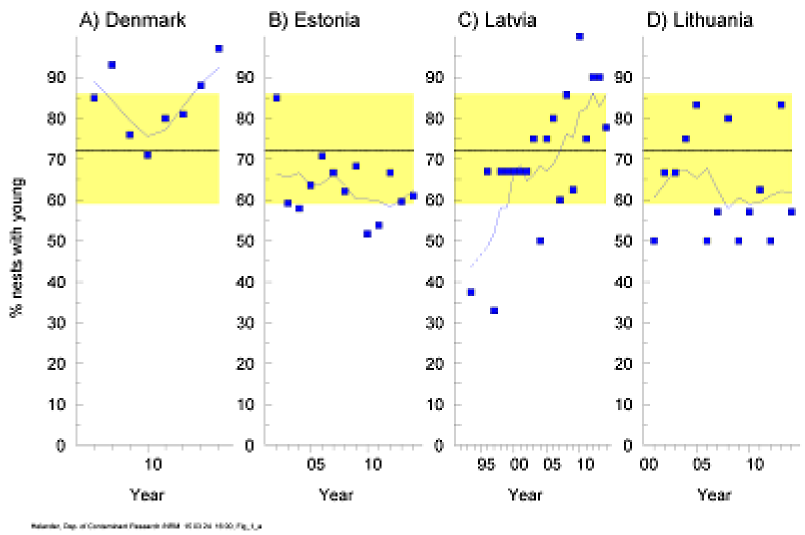


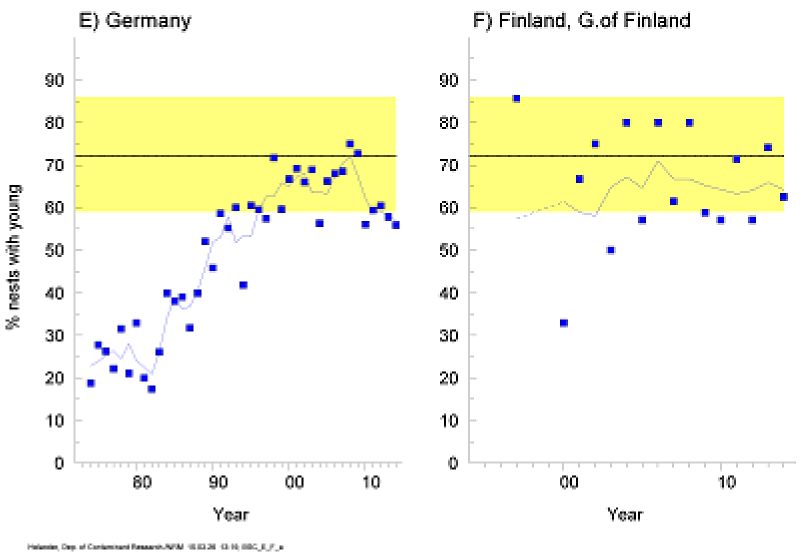
Results figure 8. The status of breeding success of the white-tailed eagle during 2007-2014 in the Baltic Sea (10 km coastal zone around the sea). The breeding success score indicates the percentage nests with young out of all checked pairs (8-year average). Red colour indicates a score below the target for good environmental status (GES). Germany is represented by data from Mecklenburg- Western Pomerania. Polish data cover the years 2012-2014.

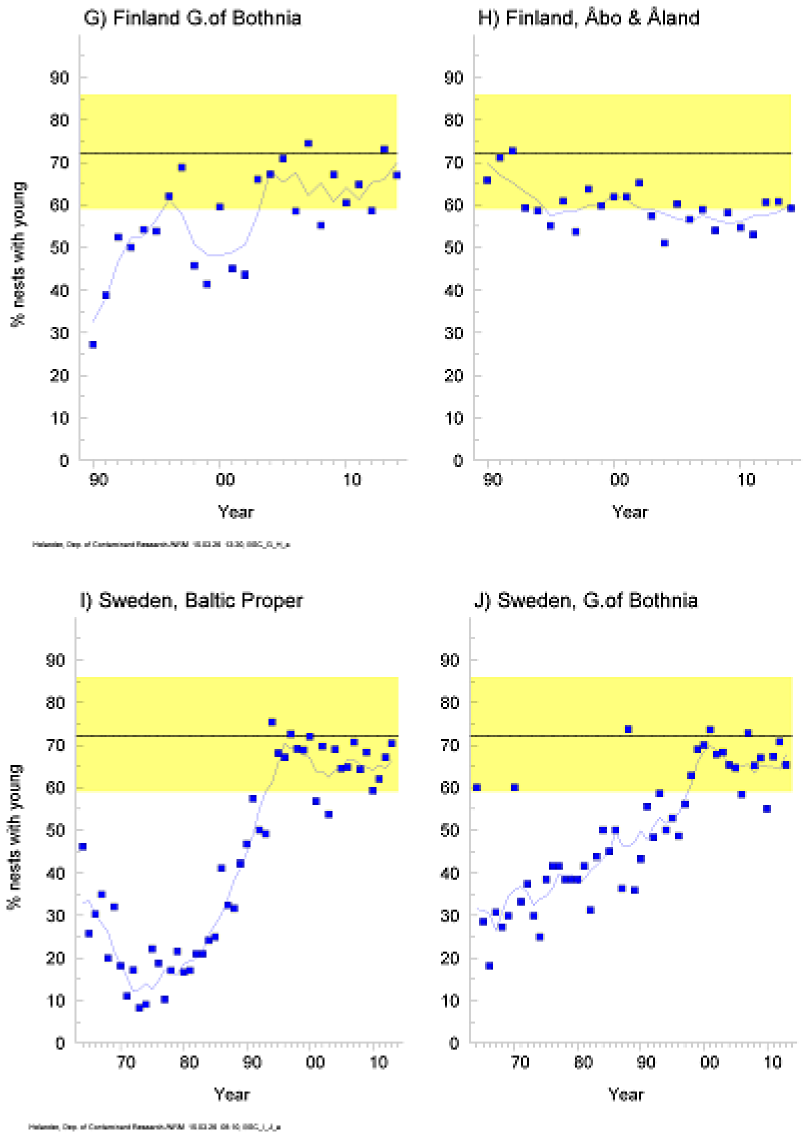


Results figure 9. Breeding success (% reproducing pairs) in the white-tailed eagle population on the Swedish Baltic Sea coast. The upper dot and the blue line indicate the background reference mean value with 95% confidence interval (grey) for a time period 1915-1953, based on data from eight eagle territories (n=43). The lower dot indicates a mean value for the time period 1954-1963 based on data from 14 territories (n=68).

Breeding success increased significantly from the early 1980s (Germany, Sweden) and generally reached GES by the mid- to late 1990s (Results figure 9). The development in the southern Baltic Sea (Germany) is similar to that in the central parts (Sweden, Baltic Proper and Finland, Åland-Åboland). Impacts of intraspecific competition in areas with a high density of breeding pairs in Mecklenburg-Western Pomerania have been discussed as a possible reason for lower breeding success (Hauff 2009; Heuck & Albrecht 2012). In densely populated areas also in Sweden and Finland, fatal territorial fights have been recorded more frequently in recent years. It may be that intraspecific competition in densely populated areas could explain why breeding success in several areas seems to have stabilized at levels slightly below the mean value for the estimated reference level indicated in Results figure 9. A lower breeding success also inherently affects productivity. The reference level is based on data from a more sparse population during the first half of the 20th century.







Results figure 10. Breeding success in % (proportion of successfully reproducing out of all checked territorial pairs) of coastal white-tailed sea eagle subpopulations around the Baltic Sea. The blue line represents a locally weighted scatterplot smoothing (LOESS). A pre-1954 reference level (black line) with 95% confidence limits (yellow area) according to Helander (2003a) is given in each graph. Germany is represented by data from Mecklenburg-Western Pomerania.

Confidence of the indicator status evaluation

The confidence of the indicator status evaluation is considered to be high. Annual data is currently available from nine countries, covering almost the entire Baltic Sea coastal area. White-tailed eagle reproduction has been monitored on an annual basis around the Baltic Sea for decades and the available historical data for all three evaluated parameters is considered to increase the overall confidence of the indicator evaluation.

There is no bias in the spatial distribution of the data. The parameters are robust and the comparability of data from different areas is high. Annual sample sizes are big for countries with long stretches of coastline and are adequate for other countries based on averages for 5-10 year periods. The national monitoring is generally focused on the whole population.

Good Environmental Status

Good environmental status (GES) in terms of white-tailed eagle reproduction is evaluated using the parameter 'productivity' and the two supporting parameters 'brood size' and 'breeding success'. For an assessment unit to be evaluated as having achieved GES, all three parameters have to achieve GES. The GES boundary for the parameters is based on an acceptable deviation from the target level determined during a reference period.

Reference levels

The reference levels are based on actual reference status data collected from the Swedish Baltic Sea coast. Breeding success data cover 1915-1953 and nestling brood size data from the period 1858-1950. The target level for productivity is based on the combined data for breeding success and nestling brood size. It should be noted that the population in those times was much smaller than today and was most probably under no influence of density-dependent effects.

Due to the lack of reference data from other parts of the Baltic Sea, the same reference level has been tentatively used for the entire Baltic Sea coastal zone. Where possible, the applicability of the reference level and the resulting GES boundaries should be validated using data from other parts of the Baltic Sea.

Breeding success

The reference level of breeding success has been determined based on data from the period 1915-1953 (n=43 years). The data has been assembled as series of records over time periods of 3-10 years in succession from eight white-tailed eagle territories. The mean value of successful nests was 72%, and the 95% confidence interval ranges from 59% to 86% based on binomial distribution.

Brood size

The reference level for brood size has been determined based on data on white-tailed eagle nestling brood size retrieved from banding records and from literature, comprising a total of 91 broods from the period 1858-1950. The recorded brood size can only result in a discrete number (1, 2 or 3 nestlings). Up to 1950, the arithmetic mean for nestling brood size was 1.84. The distribution for samples taken from such a population cannot be expected to be normally distributed. In order to investigate the true sample distribution, for estimation of a confidence interval around the mean value for brood size, samples of 25 individual brood sizes were randomly taken from the population using the 1858 – 1950 dataset. This was repeated 1,000 times (bootstrapping). The estimated sample distribution deviates significantly from the normal distribution ($p<0.03$). An estimated 95% confidence interval for a sample size of 25 was between 1.64 and 2.04.

Productivity

The reference level for productivity has been derived by combining the reference levels for brood size and breeding success. This gives a reference level for mean productivity of 1.84 x 0.72 = 1.32, with confidence limits from 1.64 x 0.59 = 0.97 up to 2.04 x 0.86 = 1.75. This estimate of confidence interval has been used in previous assessments. A more stringent estimate based on frequency distributions was derived from the dataset for nestling brood size (n = 91, all successful breeding attempts) with the addition of 35 'fictive' unsuccessful breeding attempts, based on the mean value of 72% breeding success in the population. The

95% confidence interval around the mean value of 1.32 was estimated with the same method as for nestling brood size above (bootstrapping) and is from 1.15 to 1.50. This confidence interval is built from a population that was probably under no influence from density dependent mechanisms. Under current conditions, it might be more appropriate to apply the wider interval given above, and setting the lower end at 0.97.

GES boundary

The target used to determine whether GES is achieved or not is set to the lower 95% confidence limit of the observations during the reference period. The data for the three parameters are presented as time trends. Observations should be measured as averages for a recent five to 10 year-period (depending on sample sizes). The current GES evaluation is based on an 8-year assessment period.

Productivity

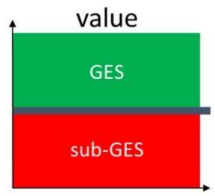
The GES boundary for productivity is 0.97 nestlings.

Brood size

The GES-boundary for brood size is 1.64 nestlings.

Breeding success

The GES-boundary for breeding success is 0.59 (59%).



Good environmental status figure 1. The boundary between GES and sub-GES is based on an acceptable deviation from the target level determined during a reference period.

The confidence of the GES boundary based on the reference levels is considered to be high as it has been determined based on carefully selected actual observations from the time period 1854-1953.

Assessment Protocol

For the assessment of Good Environmental Status (GES), a mean value based on data from a recent five to 10 year period for each of the three parameters is evaluated against its GES boundary (and when appropriate, tested with the chi-square or equivalent method). Simple log-linear regression analysis is carried out to investigate average changes over time. To check for significant nonlinear trend components, a LOESS smoother is applied and an analysis of variance is used to check whether the smoother explains significantly more than the regression line (Cleveland 1979; Nicholson et al. 1995). Statistical power analysis is used to estimate the minimum annual trend likely to be detected at a statistical power of 80% during a monitoring period of 10 years.

Methodology of data analyses

In the following three paragraphs, n1 denotes the number of nests containing 1 young (etcetera).

Productivity

The mean number of nestlings, of at least three weeks of age, out of all occupied nests:

(n1 + [n2x2] + [n3x3]) / (n0 + n1 + n2 + n3).

For nests with young that were observed only from the ground, the numbers of nestlings is underestimated since sometimes not all nestlings are visible. A correction is necessary before the total number of nestlings from such observations can be incorporated with the total number of nestlings from climbed nests, to make up the total number of nestlings for the productivity assessment. A correction is calculated based on the mean number of nestlings in climbed nests divided by the mean number of nestlings observed from the ground, or by applying the mean nestling brood size in climbed nests to all successful nests that were observed only from the ground.

Brood size

The mean number of nestlings, of at least three weeks of age, in nests containing young:

(n1 + [n2x2] + [n3x3]) / (n1 + n2 + n3).

For the calculations of mean brood size only data obtained from nests that have been climbed are included. Even big nestlings that are lying down in the nest are easily overlooked when observations are made from the ground. Data received from observations made from the ground in Germany underestimated the real number of nestlings by 11% (Hauff & Wölfel 2002), using an extended data set (updated until 2014) the difference was 14% (Herrmann, unpublished).

Breeding success

The proportion of nests containing at least one nestling, of at least three weeks of age, out of all occupied nests:

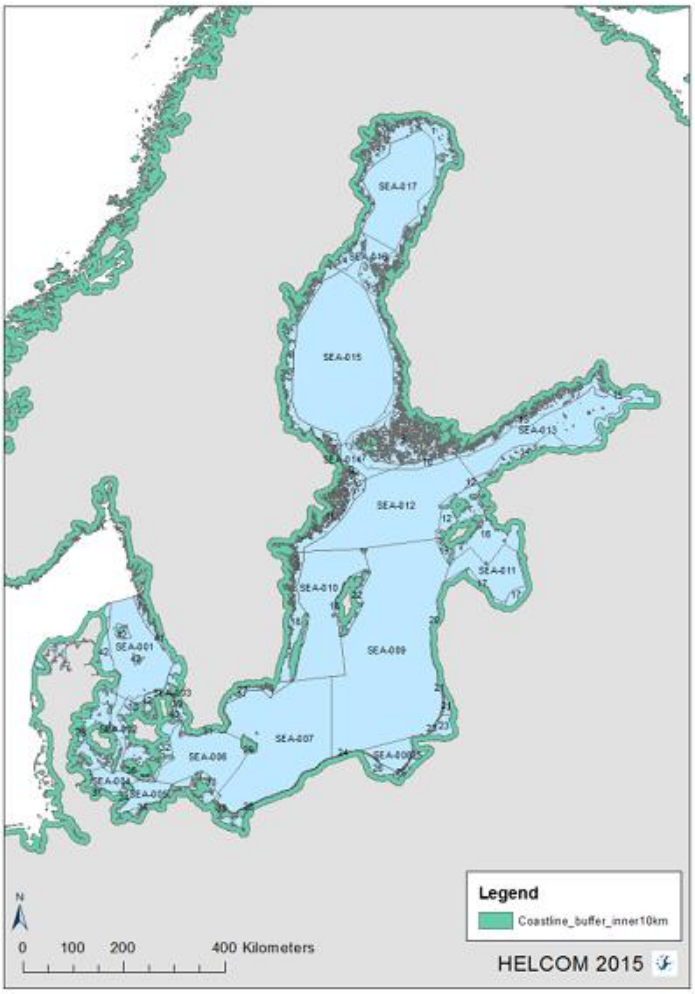
(n1 + [n2] + [n3]) / (n0 + n1 + n2 + n3).

Assessment units

White-tailed eagles are presently breeding in coastal areas of the whole Baltic Sea. In this evaluation the HELCOM assessment unit scale 3 'Open sub-basin and coastal waters' has been applied. The assessment units are defined in the HELCOM Monitoring and Assessment Strategy Annex 4.

Where a sub-population within a coastal strip of a marine assessment unit is too small from a statistical point of view, data from coastal strips of adjacent units can be combined. However, since the assessment of GES is based on data from a period of at least five years, it will yield a reasonable sample size even for small sub-populations. For example, the sub-population on coastal strip # 15 (Russian part of the Gulf of Finland) has been reported to be only 6 pairs. Over a five year period this would yield a potential sample size of 30, provided that data from all pairs can be collected in all years. This is not the case so far, and the currently available samples are useful only for calculations of mean nestling brood size (Results figure 1).

Besides breeding in coastal areas, white-tailed eagles also breed inland within all Baltic Sea coastal countries. The boundaries for coastal areas where this indicator applies are set in accordance with Article 1 of the Helsinki Convention (Convention Area) to include landward internal waters (lagoons and estuaries) (see Assessment protocol figure 1). The inner landward boundary is set in accordance with the Guidelines for the identification of coastal ecosystems proposed by EC Nature (EC Nat 2-5, 1993) and approved by EC 4, stating under point 1.2: 'For practical reasons in cases where the extension of coastal ecosystems is difficult to define according to a) – c), a strip in a width of at most 10 kilometers inland from the coastal mean water line is taken for a working area of Art. 15.'



Assessment Protocol figure 1. Only white-tailed eagle pairs breeding within the 10 km zone are considered in the indicator.

Relevance of the Indicator

Hazardous substances assessment

The status of the Baltic Sea marine environment in terms of contamination by hazardous substances is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based evaluation of the status of white-tailed eagle productivity, this indicator will also contribute to the next overall hazardous substances assessment to be completed in 2018 along with the other hazardous substances core indicators.

Policy relevance

The white-tailed sea eagle populations declined significantly were even exterminated in many European countries in the early 1900s due to strong persecution in the 19th and early 20th centuries. The population increased again due to protection measures. A second decline began in the 1950s and continued into the 1960s and 1970s due to organic pollutants, mainly DDE (a metabolite of DDT) which caused structural changes and thinning of egg shells, and PCB which caused embryo mortality, and hence, wide-spread failure in reproduction. Reproduction in the Baltic Sea eagle population in the 1970s was reduced to one fifth of the pre-1950 background level. Following bans of DDT and PCB during the 1970s, the Baltic white-tailed eagle productivity began to recover from the mid-1980s, and since the mid-1990s is largely back to pre-1950 levels. The population on the Swedish Baltic coast has increased at 7.8% per year since 1990.

The improvement in reproduction of the Baltic white-tailed sea eagle populations came no earlier than 10 years after most countries around the Baltic had implemented bans of DDT and PCB. This is a clear reminder of the potentially long-term effects of persistent pollutants. The subsequent recovery is nevertheless important evidence of successful results due to wise political decisions.

The indicator on white-tailed eagle productivity addresses the Baltic Sea Action Plan (BSAP) Biodiversity and nature conservation segment's ecological objective 'Viable populations of species'.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status (European Commission 2008):

Descriptor 1: 'Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions';

Descriptor 4: 'All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity'.

Descriptor 8: 'Concentrations of contaminants are at levels not giving rise to pollution effects'.

and the following criteria of the Commission Decision (European Commission 2010):

- Criterion 1.1 (species distribution)
- Criterion 1.2 (population size)
- Criterion 1.3 (Population condition, i.e. fecundity rates)
- Criterion 4.1 (Productivity of key species or trophic groups)

- Criterion 4.3 (Abundance/ distribution of key trophic groups and species)
- Criterion 8.2 (Effects of contaminants ("Contaminants are at a level not giving rise to pollution effects").

As a top predator in aquatic ecosystems in general, the white-tailed sea eagle is relevant for the Water Framework Directive (2000/60/EC) in relation to the objective Chemical quality, as indicator for detrimental effects of pollutants.

The EU Birds Directive (79/409/EEC) lists the white-tailed sea eagle in Annex I, binding member states to undertake measures to secure reproduction and survival of the species. The species is also listed in the following international conventions:

- Bern Convention Annex II (strictly protected species)
- Bonn Convention Annex I and II (conservation of migratory species)
- Washington Convention (CITES) Annex I (regulating trade).

Monitoring of sea eagle population health as an environmental indicator, as well as monitoring of contaminants in eagles and their prey, is recommended in an international Species Action Plan adopted under the Bern Convention in 2002. In Sweden, reproductive parameters of white-tailed eagle are included in the national environment monitoring program as indicators for harmful effects of contaminants since 1989. White-tailed eagle productivity, and eggshell thickness of white-tailed eagle and guillemot, is used in the Swedish implementation of the MSFD as indicators for effects from harmful substances (HVMFS 2012:18, 8.2.A and 8.2.B).

Role of white-tailed eagles in the ecosystem

The white-tailed eagle is the ultimate top predator of the Baltic ecosystem, feeding on fish, sea birds, and seals, and is thus strongly exposed to persistent chemicals that magnify in the food web. It was the first species that indicated deleterious effects from environmental pollutants in the Baltic Sea.

Within the Helsinki Convention area, white-tailed eagle preys primarily on waterfowl and fish, and to some extent on mammals, largely as carrion (seals) (Relevance table 1). The white-tailed eagle is an opportunistic hunter and the food it consumes largely reflects the availability of potential prey. Fish that dwell in shallow waters or close to the surface are particularly vulnerable to predation. Common fish prey species in the Baltic Sea coastal ecosystems include pike (*Esox lucius*), bream (*Abramis brama*), Ide (*Leuciscus idus*) and perch (*Perca fluviatilis*). A species that has increased strongly as prey in recent years in the Baltic Proper is garfish (*Belone belone*), probably as a result of increased availability but possibly also as a substitute for local decreases in the abundance of pike. Most common among bird prey are eider (*Somateria mollissima*), mergansers (*Mergus merganser, M.serrator*), mallard (*Anas platyrhynchos*), cormorants (*Phalacrocorax carbosinesis*), gulls (*Laridae* spp.), great-crested grebe (*Podiceps cristatus*), and coot (*Fulica atra*). A clear shift from a dominance of fish prey near the mainland shore to a dominance of bird prey in the outer archipelago has been observed (Helander 1983). A shift among bird species has also been observed, reflecting differences in availability from mainland to outer coast areas. A decrease in the abundance (and thus availability) of eider has been compensated for by the increase in abundance of cormorants. The prey distributions seem to be largely similar in different parts of the Baltic Sea, but the proportions of the prey species have not been studied in all sub-basins.

Relevance table 1. Prey of white-tailed eagle in the Baltic Sea sub-basins.

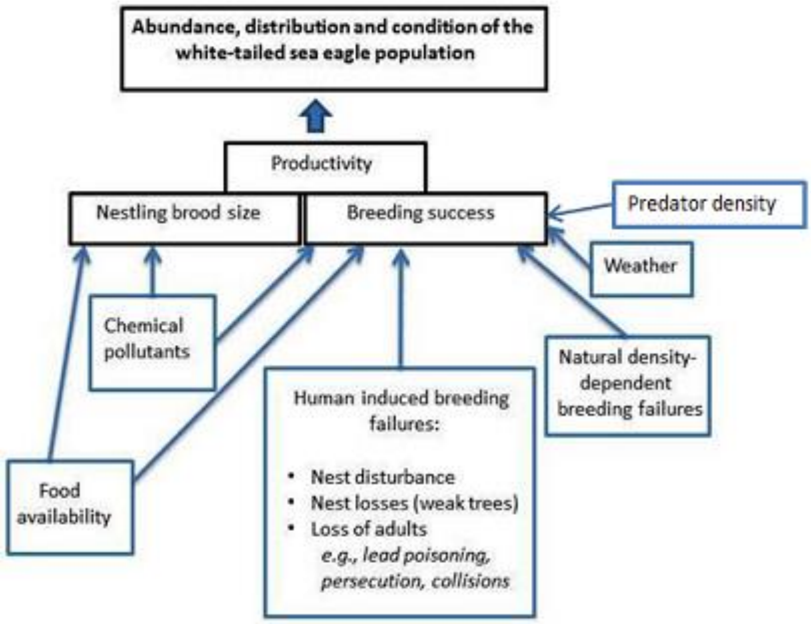
	Waterbirds	Fish	Mammals	Other
Gulf of Bothnia	55%	34%	11% (carcasses)	
Åland Sea + Archipelago Sea	58–66%	28–36%	no data	6–8%
Gulf of Finland	yes	yes	yes	seal carcasses
Northern & Central Baltic Proper + Gulf of Riga	58%	36%	seal carcasses	8%
Southern Baltic Proper	waterfowl, geese	yes	carcasses of deer and wild boar	
Danish Straits and German Bights	waterfowl, geese	yes	carcasses	
Kattegat+ Limfjorden	waterfowl, geese	yes	carcasses	

In addition to being a top predator, the white-tailed eagle has other features that are favourable from a monitoring perspective. Territorial adults on the Baltic Sea coast are mainly sedentary and thus reflect the regional contaminant situation. Mating pairs generally pair for life and remain at the same breeding site, with sites commonly used over many generations of eagles. This provides very good opportunities for long-term monitoring and detailed studies. A large portion of breeders in the Baltic Sea region are currently ringed, improving possibilities for study of individual birds over time.

Human pressures linked to the indicator

	General	MSFD Annex III, Table 2
Strong link	The most important human threat to white-tailed eagles in modern times has been effects of toxins affecting population health (reproduction)	Contamination by hazardous substances • introduction of synthetic compounds
Weak link	Enhanced mortality from collisions (trains, wind farms etc.) Enhanced mortality from secondary poisoning by lead ammunition Vulnerable to direct persecution (now illegal). Habitat loss and prey depletion are potentially serious future threats	

The productivity of the white-tailed sea eagle is affected by several human pressures that affect the nestling brood size (number of nestlings) and breeding success (success in raising at least one nestling per pair).

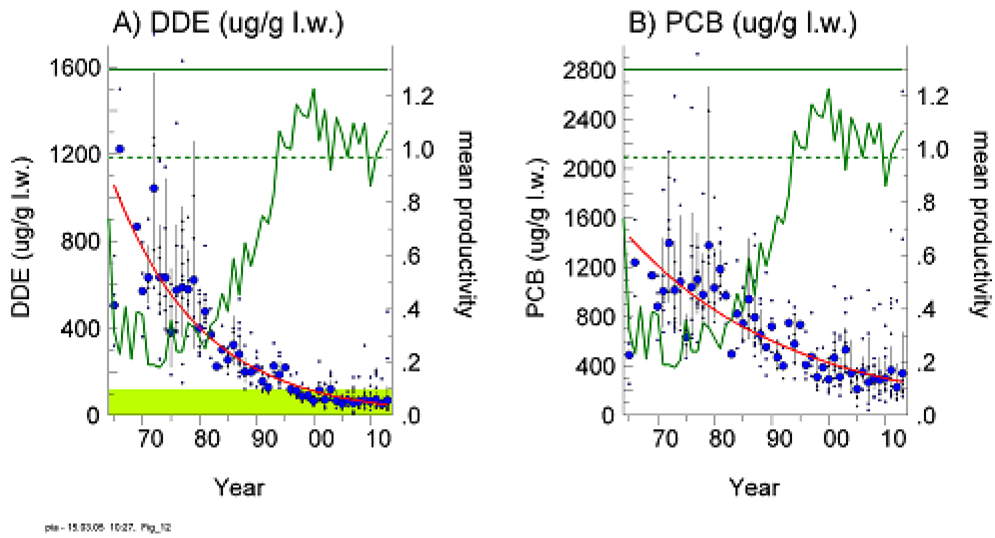


Relevance figure 1. Relationship of white-tailed eagle productivity parameters and underlying pressures. "Nest losses (weak trees)" (Human induced breeding failures) refers to an increasing shortage of suitable nest trees in cultivated forests.

Contaminant burdens

The human pressure that has most clearly affected white-tailed eagles after it was legally protected is the introduction of hazardous substances to the environment. Chemical analyses of the contents of collected dead eggs have provided possibilities to study relationships between the concentrations of contaminants and reproduction. Tissue and egg samples of white-tailed eagles have contained among the highest residue concentrations of persistent organochlorine contaminants (e.g. DDTs and PCBs) and heavy metals ever documented in the Baltic Sea area and the world (Henriksson et al. 1966; Jensen 1966; Jensen et al. 1972; Koivusaari et al. 1980; Helander 1994b; Helander et al. 1982, 2002, 2008; Olsson et al. 2000; Nordlöf et al. 2010). Furthermore, studies of individual eagles over time showed that females that were exposed to high concentrations of contaminants during the 1960s and 1970s remained unproductive after residue concentrations in their eggs had declined, indicating persistent effects from previous exposure (Helander et al. 2002).

Trends in productivity and residue concentrations of DDE and PCBs show that residue concentrations of DDE have now generally declined below an estimated critical threshold level for affecting reproduction (Relevance figure 2), but exceptions with very high concentrations have turned up during 2009-2013 among sea eagle eggs from the Gulf of Bothnia.



Relevance figure 2. Mean annual productivity (number of nestlings per checked occupied territory) and residue concentrations of DDE and total-PCB (µg/g, lipid weight) in white-tailed eagle eggs from the Swedish Baltic coast during 1965-2013. The shaded green area in the left graph indicates a range of concentrations below a previously estimated lowest-observable-effect-level (LOEL) for DDE according to Helander et al. (2002). Large dots = annual geometric means; small dots = individual clutches; vertical lines = 95% confidence limits (for sample sizes > 3). Regression lines for DDE and PCB in the eggs decreased significantly during the study periods ($p<0.001$). Productivity of the coastal population increased significantly ($p<0.001$). In a reference freshwater population in Swedish Lapland (not shown here), the concentrations of DDE were below the estimated LOEL and there was no statistically significant change in productivity over the study period.

Since predatory birds are highly exposed to persistent chemicals they are useful for detecting the presence of 'new' pollutants that are potentially harmful, as illustrated by the discovery of PCBs in 1966 in a Baltic white-tailed eagle (Jensen 1966) and the discovery of the flame retardant congener PBD-209 in peregrine falcon eggs in 2004 (Lindberg et al. 2004). Residue concentrations of brominated flame retardants have been investigated in eagle egg samples from Sweden, (Nordlöf et al. 2010) and concentrations in the Baltic samples were three and six times higher than those from inland samples from southern Sweden and Lapland, respectively. Lethal poisoning connected with consumption of lead ammunition has also been observed to be an important cause of death in white-tailed eagle populations (Krone et al 2006).

Other factors

The massive development of wind power parks can lead to a significant increase in mortality among white-tailed eagles and can be seen as a reduction in breeding success and productivity (Dahl et al. 2012), but not in nestling brood size. Weather conditions can affect breeding success and productivity, and it will be interesting to follow the possible effects due to climate change.

In theory, also food shortages affect brood size and breeding success, but this has so far not been observed in the Baltic Sea population, where there has been, so far, plenty of food. Body mass can be indicative of food stress and health and such data can usually be easily obtained when assessing reproductive output in the nests and handling nestlings.

Relevance of the indicator for status assessment

Using white-tailed eagle productivity as a core indicator for assessing Good Environmental Status (GES) in relation to hazardous substances relies on the experience of the effects of exposure to persistent contaminants on this species over five decades on the Baltic Sea coast. If white-tailed sea eagle reproduction had been monitored in the Baltic Sea earlier during the 20th century, then the negative impact of DDT could have been noticed already in the 1950s. Retrospective studies have shown a significant drop in white-tailed eagle breeding success and nestling brood size already in the 1950s, with a further decrease during the 1960s and 1970s (Helander 1985). High concentrations of DDTs and PCBs in white-tailed eagle eggs were reported early from Finland (Koivusaari et al. 1980) and Sweden (Helander et al. 1982) and significant relationships were shown between productivity and residue concentrations of DDE and PCB in white-tailed eagle eggs (Helander et al. 1982, 1994b, 2002, 2008).

Productivity parameter

The productivity of white-tailed eagle in the coastal zone of different parts of the Baltic Sea is an indicator describing not only the effects from biomagnification of contaminants, but also persecution, disturbance of nest sites, food availability and availability of suitable nesting sites. Thus, it describes in reproductive terms the condition of the population and indirectly indicates the potential for increased abundance and distribution. This indicator combines the breeding success and brood size into a single indicator and assesses the reproductive output of the population. It is a useful indicator in studies on relationships between reproduction and human pressures and also a vital parameter in assessments of the state of populations from management perspectives.

Brood size and breeding success as supporting parameters

Brood size is a precise parameter following the number of nestlings produced per nest containing young. This is a good indicator for impacts of hazardous substances because as top predators, white-tailed eagles accumulate persistent toxins which in turn can cause egg mortality. Breeding success (per cent pairs in the population that produce young) is another indicator for egg mortality, including effects from contaminants and also other anthropogenic disturbance as well as natural factors such as weather, and density dependent breeding failures.

Monitoring Requirements

Monitoring methodology

The HELCOM common monitoring relevant on white-tailed eagles is described on a general level in the **HELCOM Monitoring Manual in the sub-programme: Marine bird health**.

In addition to the annual monitoring described in the Monitoring Manual, data are collected from eagles found dead in nature. Such specimens belong to the state in all countries around the Baltic Sea, except for in Germany. This provides good opportunities for investigations of the cause of death. State game is normally sent to the national authority for registration and examination of death cause, saving of samples and preparation for museum collections. Professional investigations of causes of death in white-tailed eagles are performed in Finland, Germany and Sweden (and possibly elsewhere). Before being opened, all white-tailed sea eagles are inspected macroscopically for body condition and signs of trauma, and x-rayed to assess the presence of lead shot, fractures etc. Distributions of cause of death of sea eagles from Germany, Finland and Sweden are presented in Herrmann et al. (2011). In Finland, Germany and Sweden, organ samples are archived from all reasonably fresh specimens.

Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the Monitoring Concepts table.

Sub-programme: Marine bird health
Monitoring Concepts table

Current monitoring, which is carried out by the HELCOM Contracting Parties on an annual basis, is considered adequate.

At present, eagles are breeding along the coasts of almost the whole of the Baltic Sea, as well as in inland freshwater systems within the Baltic Sea catchment area. Populations and reproduction are monitored in a network of national projects that use the same methodology (Helander 1990). Monitoring of white-tailed eagle reproduction in Sweden has been included in the National Environment Monitoring Programme since 1989 as an indicator of the effects from chemical pollutants. Pre-1954 background data on breeding success and pre-1950 background data on nestling brood size are available from the Swedish Baltic coastline (Helander 1994a, 2003a). These data are used as reference levels for evaluation of observations within the programme (see below). The current numbers of known territorial pairs in the HELCOM coastal area are given below (Monitoring table 1). The coastal area is restricted to the 10 km from the coastal zone, with the majority of eagles breeding close to the coastline and in the archipelagos.

White-tailed eagles breeding inland in freshwater habitats are usually monitored in the same way as the coastal populations. Freshwater populations are much less exposed to contaminants and observed differences in data can be used to compare exposure to different pressures faced by inland and coastal eagles (Helander et al. 2002).

Monitoring table 1. The number of breeding white-tailed sea eagle pairs monitored and considered in the indicator evaluation.

Contracting Party	Sub-area if relevant	Number of breeding white-tailed eagle pairs within the 10km coastal strip	Number of pairs breeding and feeding inland/freshwater, given for reference
Denmark		>30 pairs	c.15 pairs
Estonia		>100 pairs	35 pairs
Finland	Gulf of Bothnia (Quark)	>100 pairs	c. 50 pairs
	Åland & Åboland	>250 pairs	
	Gulf of Finland	30 pairs	
Germany	Mecklenburg-Pomerania	>110 pairs	c. 200 pairs
	Schleswig-Holstein	>20 pairs	c. 50 pairs
Latvia		10 pairs	c. 40 pairs
Lithuania		9 pairs	c. 50 pairs
Poland		88 pairs	>500 pairs
Russia		6 pairs	Not known but believed to be large
Sweden	Gulf of Bothnia	>120 pairs	>75 pairs
	Baltic Proper	>200 pairs	>150 pairs

Description of optimal monitoring

During spring (February – April, incubation period) eagle territories are checked from a safe distance (to avoid disturbance) in order to locate occupied nests. Occupied nests are to be revisited during the nestling period (May – June) for assessment of breeding success and nestling brood size.

It is crucial for the assessment of breeding success and productivity that unsuccessful as well as successful breeding attempts are recorded equally well. Most breeding failures occur during the early phases of the breeding cycle. The early spring surveys are therefore very important as later during the breeding season there is an increasing risk that unsuccessful breeding attempts are overlooked. A very effective way to perform the early survey in spring is by helicopter. The importance of conducting a first check during the incubation period, to be followed by a second check during the nestling period, has been stressed previously by Postupalsky (1974; 1981; 1983), Steenhof (1987) and Steenhof & Newton (2007).

For the assessment of nestling brood size, it is crucial that the nest content is checked properly by climbing to the nest (or a neighbouring tree) in order to be able to look into the nest. Nests checked only from the ground are not used for assessment of nestling brood size. The number of nestlings in successful nests observed only from the ground is estimated by applying a correction factor before being used for calculation of productivity. For the future, Unmanned Airborne Systems (UAS) may provide good opportunities for the checking of unclimbed nest to assess actual nestling brood size.

Data and updating

Access and use

The data and resulting data products (tables, figures and maps) available on the indicator web pages can be used freely given that the source is cited. The indicator should be cited as following:

HELCOM (2016) White-tailed eagle productivity**.** HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN: 2343-2543

Metadata

Results in this core indicator report are based on data from the following time series: Denmark 2007-2014, Estonia 2002-2014. Finland 1990–2014, Germany – Federal State Mecklenburg-Western Pomerania 1973–2014, Latvia 1992-2014, Lithuania 2001-2014, Russia 1993-2014, Sweden 1964-2013, Poland 2007-2014.

Spatial coverage includes the whole HELCOM Convention area although there are large differences in the size of national eagle populations (see Monitoring table 1).

The new reporting format discriminates between controls of climbed nests and nests that have been observed only from ground level, in order to allow for calculations of a correction factor based on the data for each national population/sub-area. The correction factor relates to nestling brood size for nests that has been checked only from ground level and is needed for correct estimates of productivity for such nests (see also Description of optimal monitoring).

Strengths and weaknesses of data

Minimum detectable yearly trend (%) for a 10-year monitoring period, at a statistical power of 80%, has been estimated for Swedish data for different sample sizes, based on random sampling from data collected during 1991–2006 (Helander et al. 2008). Minimum detectable trends based on the raw dataset between 1991–2006 (with a varying annual number of observations) was 1.3% for brood size (Baltic Proper), 2.0% for breeding success (Gulf of Bothnia) and 3.0% for productivity (Gulf of Bothnia). The national survey methods are very similar but population size and thus sample sizes vary between the Contracting Parties.

Data source

In most countries the monitoring and handling of data is carried out on a voluntary basis, often in national projects with devoted members. National data have been submitted from the contracting parties to the Swedish Museum of Natural History for storage and compilation of results in uniform format. The following are examples of national monitoring performance and data handling:

Denmark: Monitoring and data storage is carried out on a voluntary basis within the national project "Örn" under the Danish Ornithological Society.

Estonia: Monitoring and data storage is carried out on a voluntary basis by the national "Eagle Club".

Finland: Surveys of breeding populations and reproduction, ringing of nestlings and sampling are carried out by voluntary members of WWF Finland's White-tailed Sea Eagle working group. Data are stored in a competent database. Specimens found dead, DNA-samples from nestlings as well as addled eggs are stored in the Finnish Museum of Natural History, University of Helsinki.

Germany: In Western Pomerania, data are collected by voluntary ornithologists, coordinated by the "Project group for large bird species" under the auspices of the Agency for Environment, Nature Conservation and Geology. The country-wide white-tailed sea eagle data are compiled by Peter Hauff, who submits the annual reports to the mentioned governmental agency.

Sweden: Surveys of breeding populations and reproduction with sampling, sample preparation, storage in specimen bank, and evaluation and storage of data are carried out by the Department of Environmental Research and Monitoring at the Swedish Museum of Natural History, Stockholm, and are commissioned by the national EPA. Surveys of breeding populations and reproduction of reference freshwater populations have thus far been carried out by the Swedish Society for Nature Conservation ("Project Sea Eagle"). Chemical analysis is carried out at the Institute of Applied Environmental Research at Stockholm University.

Contributors and references

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Archive

This version of the HELCOM core indicator report was published in January 2016

Core indicator report – web-based version January 2016 (pdf)

Extended core indicator report – outcome of CORESET II project (pdf)

Older versions of the core indicator report are available:

2013 Indicator report

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