White-tail eagle productivity

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Key message

- Productivity has reached GES in all the studied areas (Gulf of Bothnia, Swedish Baltic Proper and Mecklenburg-Vorpommern.
- Nestling brood size, indicating the effects of contaminants, has reached GES only in the Baltic Proper and Finnish Gulf of Bothnia. The occurrence of dead eggs is significantly higher in the Swedish Gulf of Bothnia indicating a possible impact from contaminants.
- Following bans of DDT and PCB in the Baltic region during the 1970s, eagle productivity began to recover in the 1980s, and since the mid-1990s is largely back to pre-1950 levels. Reproduction in the Baltic eagle population in the 1970s was reduced to one fifth of the pre-1950 background level.

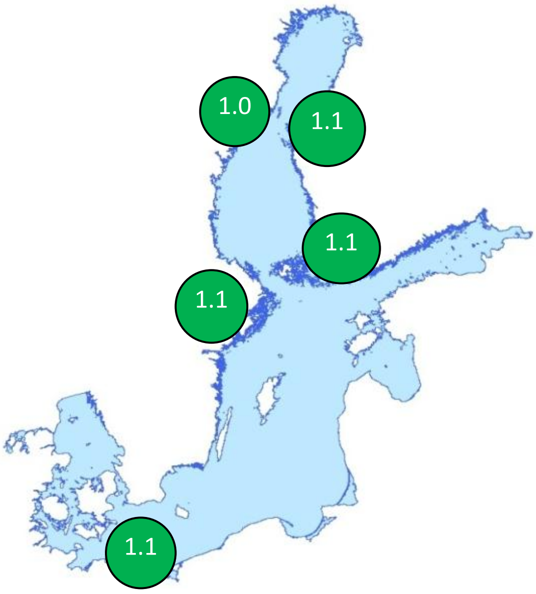

Figure 1. *The status of productivity of the white-tailed eagle in the Baltic Sea (15 km coastal zone around the sea). Green color means good environmental status (GES). The productivity score (number of nestlings per checked territorial pair, a 5-year average) is given inside the circles.*

Description of the core indicator

The productivity core indicator

The productivity of white-tailed eagle in the coastal zone of different parts of the Baltic Sea is an indicator describing not only 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 anthropogenic pressures and also a vital parameter in assessments of population status in management perspectives.

Brood size and breeding success as supporting indicators

Brood size is a 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 toxins, which in turn causes egg mortality. Breeding success is an indicator for other disturbance but may also be affected by density dependent breeding failures.

Core indicator targets

Pre-1954 background data on breeding success and pre-1950 background data on nestling brood size in Sweden are available as reference levels for evaluation of observations. In the lack of reference points in other parts of the Baltic Sea, this target has been tentatively set for the core indicator in the entire Baltic coastal zone. The productivity should be >1.0 nestling/checked territorial pair, the brood size >1.64 per nest containing young and breeding success > 60 %. These thresholds are based on the lower ends of the 95 % confidence limits for estimated background brood size and breeding success on the Swedish Baltic coast and thus refer to the coastal populations. The status is measured as an average for the last 5 years.

What is the status of White-tailed eagle in the Baltic Sea?

Productivity in the Baltic Sea is in GES

The mean annual productivity reaches good environmental status (GES) in all studied areas (Figure 1). Currently, the assessment includes Swedish and Finnish Gulf of Bothnia, Swedish Baltic Proper and the German Mecklenburg-Vorpommern.

The time series since 1970s indicate great increase in productivity and GES was reached mainly during the last 10 years. The increase has, however, started to level off in most of the studied areas and in particular in Germany, where the productivity is impacted by density-dependent competition for nest sites (Figure 2).

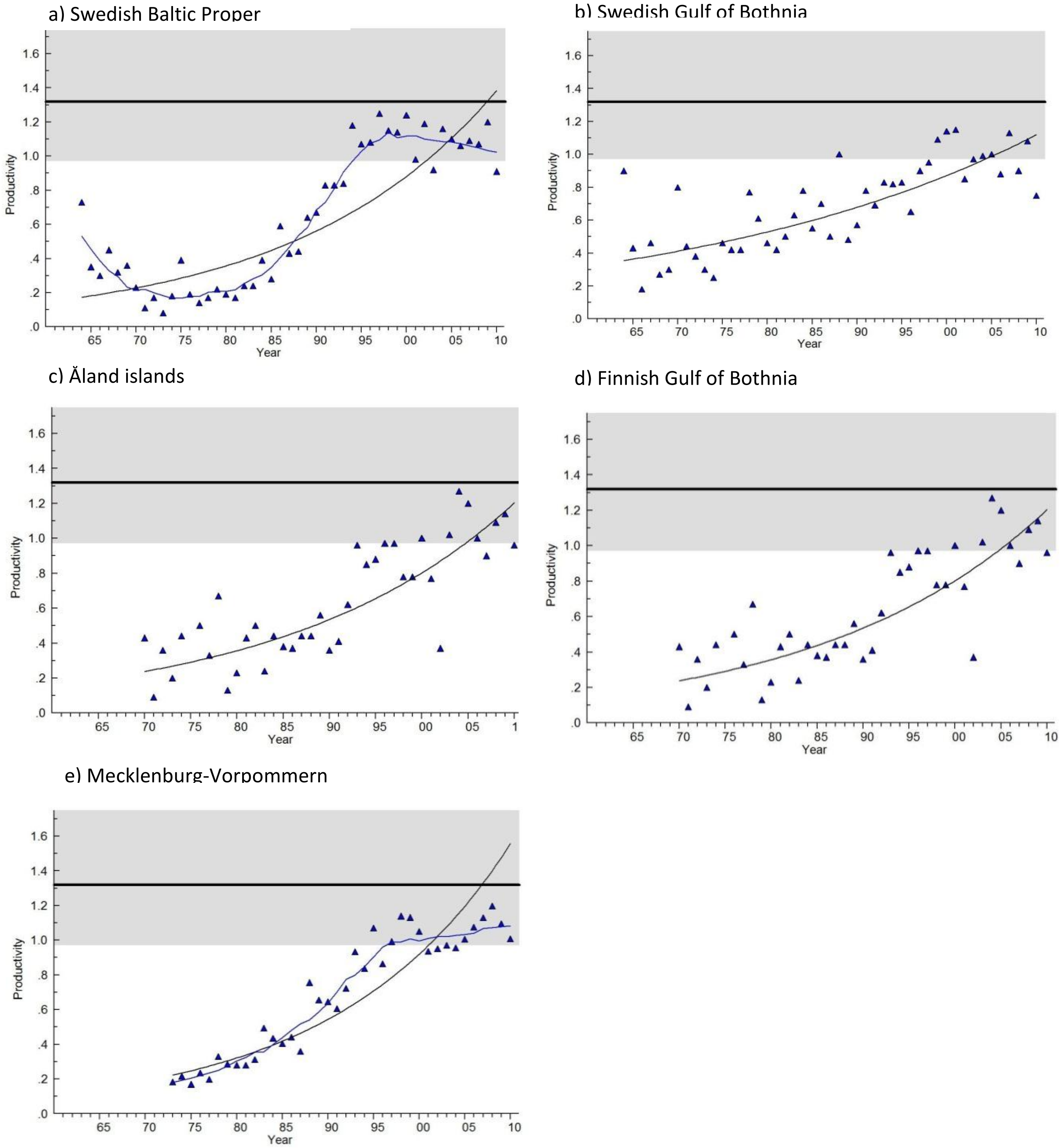

Figure 2. *Mean annual productivity (number of nestlings per checked occupied territory) of coastal subpopulations of white-tailed sea eagles in Sweden and Finland, and of costal and freshwater populations in Mecklenburg-Western Pomerania, Germany. The blue line in graph (a) and (c) represents a locally weighted scatterplot smoothing (LOESS) that explains significantly more than the linear regression line in those graphs. The data set from Germany includes nests that were inspected only from the ground in 1973–1980. A pre-1950 reference level (black line) given with a range (shaded grey) based on confidence limits for breeding success and brood size according to Helander (2003a) is given in each graph. Whether the reference level, estimated from data from the Swedish Baltic coast, is fully relevant for other populations has not been validated.*

Brood sizes show decreasing impact from contaminants

Nestling brood size reaches the level of GES in Finnish Gulf of Bothnia and Swedish Baltic Proper (Figures 3, 4). The mean brood size is still below the boundary for GES in Swedish Gulf of Bothnia, Åland islands and the German coast.

The mean brood sizes range between 1.43 and 1.80 in the studied areas. The smallest broods are found in the Bothnian Sea (<1.50 nestlings). Brood sizes began to increase in the studied areas from the 1980s, roughly in synchrony with the increase in breeding success (Figure 3). This is inherent with an improvement in the hatching success of the eggs, affecting both these indicators in parallel. Brood size reached back to the pre-1950 reference level in the Baltic Proper in the late 1990s.

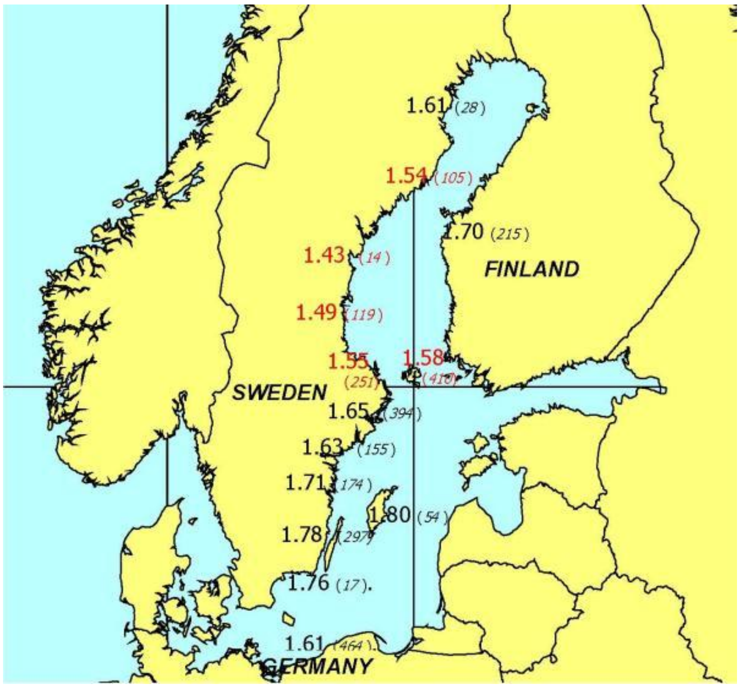

Figure 3. *Mean white-tailed sea eagle nestling brood size around the Baltic Sea in 2000 – 2010. Sample sizes given in brackets. The reference level up to 1950 based on data from the Swedish coast was 1.84, with 95 % confidence limits 1.64 –2.04 (Helander 2003a). Nestling brood sizes below 1.60 are highlighted (red) in the map. Data from Finland 1965 – 1999 are from Stjernberg et al. (2003), and completed for 2000 – 2010.*

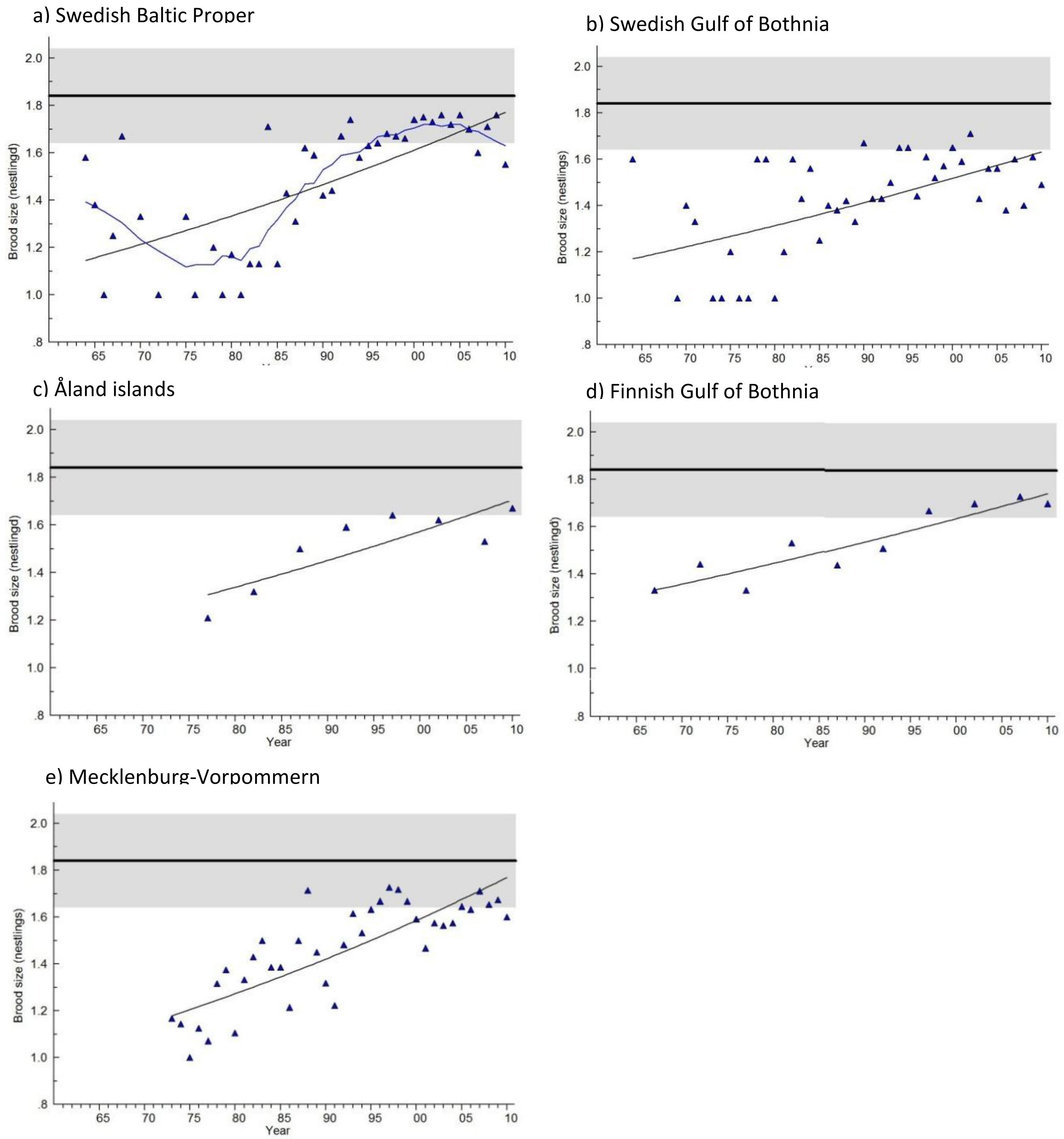

Figure 4. *Mean brood size (number of nestlings per successfully breeding pair) of coastal white-tailed sea eagle subpopulations in Sweden and Finland, and of costal and freshwater populations in Mecklenburg-Western Pomerania, Germany. The blue line in graph (a) represents a locally weighted scatterplot smoothing (LOESS) that explains significantly more than the linear regression line. A pre-1950 reference level (black line) with 95 % confidence limits (shaded grey) according to Helander (2003a) is given in each graph. Whether the reference level, estimated from data from the Swedish Baltic coast, is fully relevant for other populations has not been validated. Five-year mean values from Finland for 1965–1999 are from Stjernberg et al. (2003), and completed for 2000–2010.*

Breeding success of the White-tailed eagle

Breeding success of sea eagles has improved over time on the northern, central and southern Baltic coast (Figure 5). Retrospective studies have shown that breeding success along the whole Swedish Baltic coast decreased from an average of 72 % in the early 1950s, down to 47 % between 1954–1963, and 22 % between-1982 (Helander 1985). Breeding success increased significantly in the Baltic Proper as well as in the Gulf of Bothnia from the early 1980s. By the mid to late 1990s, breeding success in the studied areas had reached GES (Figure 5).

The development in the southern Baltic (Germany) is similar to that in the central Baltic (Sweden, Baltic Proper). 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). In densely populated areas 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 appears to have stabilized at levels slightly below the mean value for the estimated reference level in Figure 4. The reference level was based on data from a more sparse population during the first half of the 20th century.

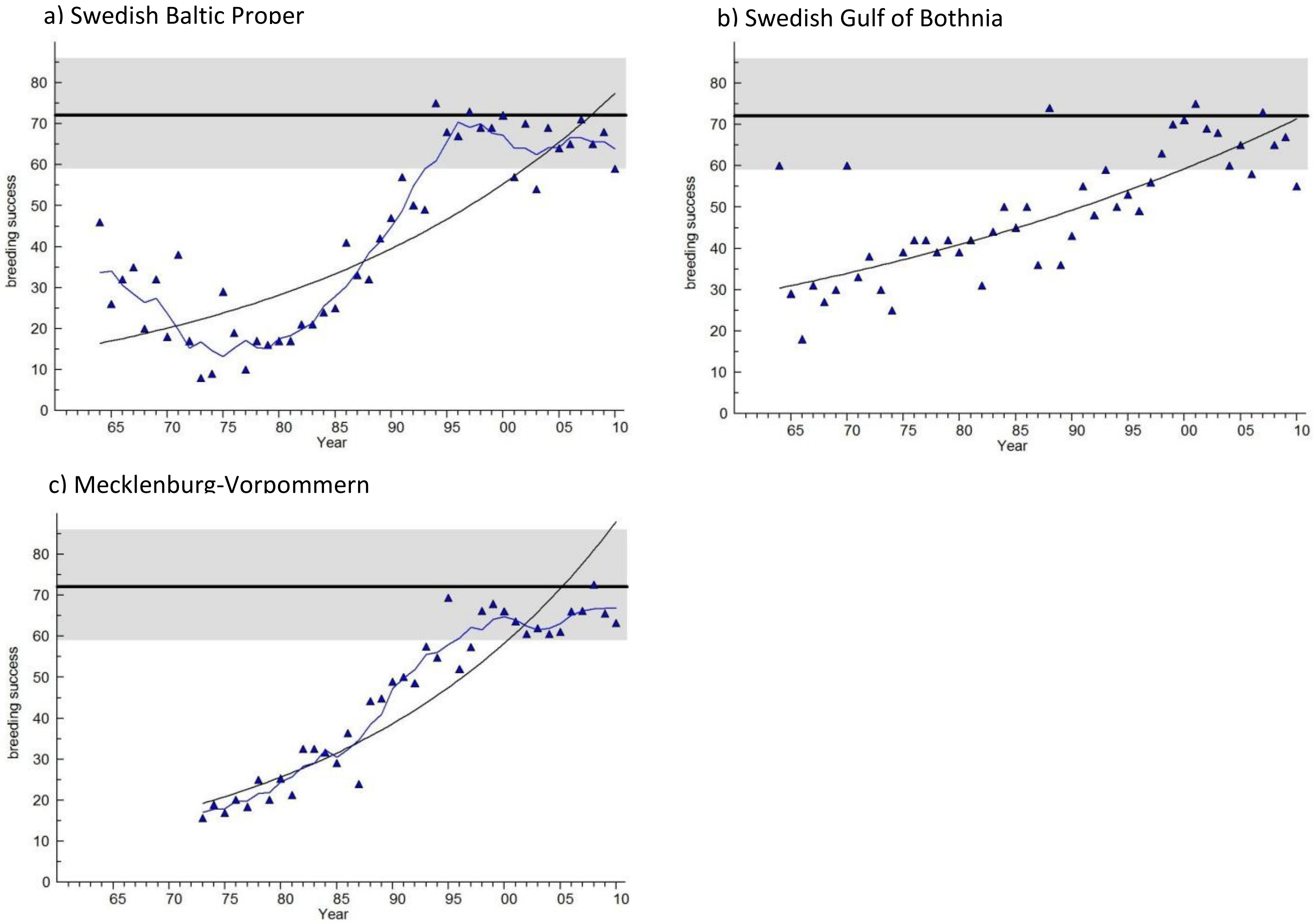

Figure 5. *Breeding success (%, number of successfully reproducing out of all checked territorial pairs) of coastal white-tailed sea eagle subpopulations in Sweden, and of coastal and freshwater populations in Mecklenburg-Western Pomerania, Germany. The blue line in graph (a) and (c) represents a locally weighted scatterplot smoothing (LOESS) that explains significantly more than the linear regression line. A pre-1950 reference level (black line) with 95 % confidence limits (shaded grey) according to Helander (2003a) is given in each graph. Whether the reference level, estimated from data from the Swedish Baltic coast, is fully relevant for other populations has not been validated.*

Policy relevance

The white-tailed sea eagle is a species that has faced strong persecution in 19th and early 20th century causing the population to crash by early 20th century. Protection measures increased the population, but in 1950s', the population crashed again because of organic pollutants, mainly DDT, which caused thinning of eggs and, hence, wide-spread failure in reproduction.

Reproduction in the Baltic eagle population in the 1970s was reduced to 1/5 of the pre-1950 background level. Following bans of DDT and PCB during the 1970s around the Baltic, eagle productivity began to recover in the 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 from persistent pollutants. The subsequent recovery, from an 80 % reduction in reproductive ability in the 1970s, is nevertheless an important evidence of successful results from wise political decisions.

The maintenance of viable populations of species is one of the biodiversity objectives of the HELCOM Baltic Sea Action Plan. 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 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). As a top predator in the marine ecosystem, white-tailed sea eagle is also being assessed by the EU Marine Strategy Framework Directive (2008/56/EU), which requires good environmental status (GES) of marine ecosystems by 2020. Particularly the following GES criteria apply to this core indicator:

- Species distribution,
- Population size,
- Population condition,
- Productivity of key species or trophic groups.

Monitoring of sea eagle population health as 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.

How the indicator describes the Baltic marine environment

Relevance of the indicator for describing developments in the environment

The white-tailed sea eagle was the first species that indicated there were deleterious effects from environmental pollutants in the Baltic Sea. If white-tailed sea eagle reproduction had been monitored in the Baltic Sea earlier during the 20th century, the negative impact of DDT may have been noticed as early as the 1950s. The sea 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.

Currently, eagles are breeding along the coasts of the whole of the Baltic Sea, as well as in inland freshwater systems, and are monitored in a network of national projects that use the same methodology. Monitoring of sea eagle reproduction in Sweden has been included in the National Environment Monitoring Programme since 1989, as an indicator of 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). This data is used as reference levels for evaluation of observations within the programme.

Role in the food web

White-tailed eagle populations around the Baltic Sea have grown substantially during the last decades (Herrmann et al. 2011). The number of annually checked pairs in Sweden have increased in the Baltic Proper from between 20 – 30 pairs prior to 1975 to 217 pairs in 2010, and in the Gulf of Bothnia from approximately 10 pairs prior to 1975 (all in the Bothnian Sea) to 109 pairs in 2010 (including a re-occupation of the Bothnian Bay). Similarly, the total number of annually checked pairs in Finland grew from about 10–20 pairs in the early 1970s, to 300 pairs in 2010. In the sample from Mecklenburg-Western Pomerania, Germany, numbers of checked pairs increased from around 75 to 230 between 1973–2010. See the HELCOM Baltic Sea Environment Fact Sheet for White-tailed eagle population.

White-tailed eagle preys on waterfowl, fish and mammals (Table 1). The prey seems to be similar in different parts of the Baltic Sea, but the proportions of the prey species have not been studied in all sub-basins. It is, however, known that individuals may specialize on certain prey types.

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	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	

Factors affecting the white-tailed sea eagle reproductive success

Responses to anthropogenic pressures

The productivity of the white-tailed sea eagle is affected by several anthropogenic pressures acting through the nestling brood size (number of nestlings) and the breeding success (success in raising one nestling per pair).

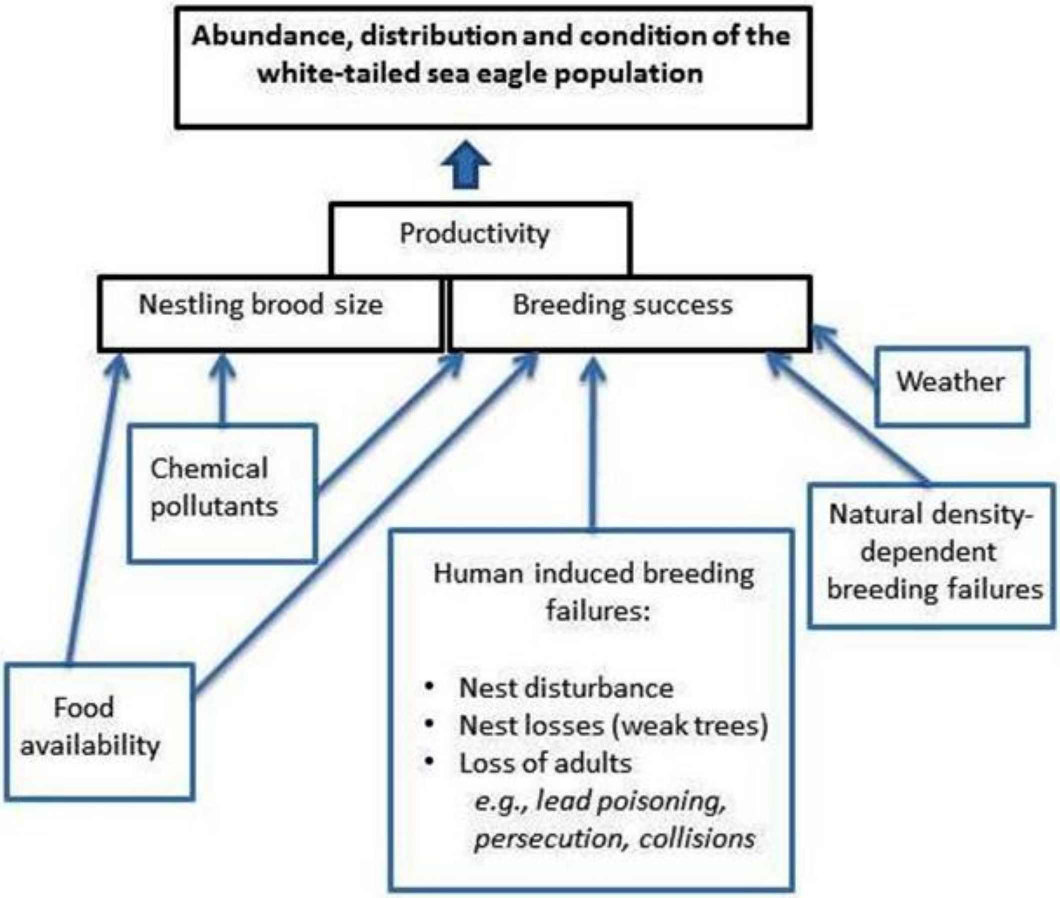

Figure 6. *Relations of the core indicator, the measured parameters and the underlying factors.*

Contaminant burdens

Brood size is an accurate indicator for effects of contaminants (Figure 7). The decrease of DDTs and PCBs in the Baltic environment has led to a significant increase in brood size. The lead contamination has, however, not decreased over the period 1981 – 2004 (Helander et al. 2009).

Tissue and egg samples of white-tailed sea eagles have contained among the highest residue concentrations of persistent organochlorine contaminants and heavy metals in the Baltic and the world (Henriksson et al. 1966, Jensen 1966, Jensen et al. 1972, Koivusaari et al. 1980, Helander 1994b, Helander et al. 1982, 2002, Olsson et al. 2000, Nordlöf et al. 2010). Predatory birds are highly exposed to persistent chemicals and are useful in detecting the presence of "new" pollutants that are potentially harmful, as illustrated by the discovery of PCBs in 1966 in a Baltic white-tailed sea eagle (Jensen 1966), and the discovery of the flame retardant congener PBD-209 in peregrine falcon eggs in 2004 (Lindberg et al. 2006).

Chemical analyses of samples of the contents from collected dead eggs provide possibilities to study relationships between the concentrations of contaminants and reproduction. In free-ranging birds, this is usually done on a population level, but more detailed studies can also be made when individual breeding pairs are followed over time periods. In addition to being highly exposed to persistent chemicals, the white-tailed sea 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, providing good opportunities for long-term studies. A large portion of breeders in the Baltic region are currently ringed, improving possibilities for study of individual birds over time.

Studies of sea eagles in the Baltic Sea have revealed strong correlations between residue concentrations of DDTs and PCBs and reproduction (Koivusaari et al. 1980, Helander 1994b, Helander et al. 1982, 2002, 2008). 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 affects 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 declined below an estimated critical threshold level for affecting reproduction (Fig. 7). Residue concentrations of brominated flame retardants have been investigated in eagle egg samples from four regions in Sweden – the Baltic Proper, Bothnian Sea, and inland freshwaters in southern Sweden and northern Sweden Lapland (Nordlöf et al. 2010). No significant difference was found between the samples from the Baltic coast. Concentrations in the Baltic samples were three and six times higher than from inland samples from southern Sweden and Lapland, respectively. Investigations on other contaminants are in progress, to search for an explanation for the smaller brood size in the Bothnian Sea.

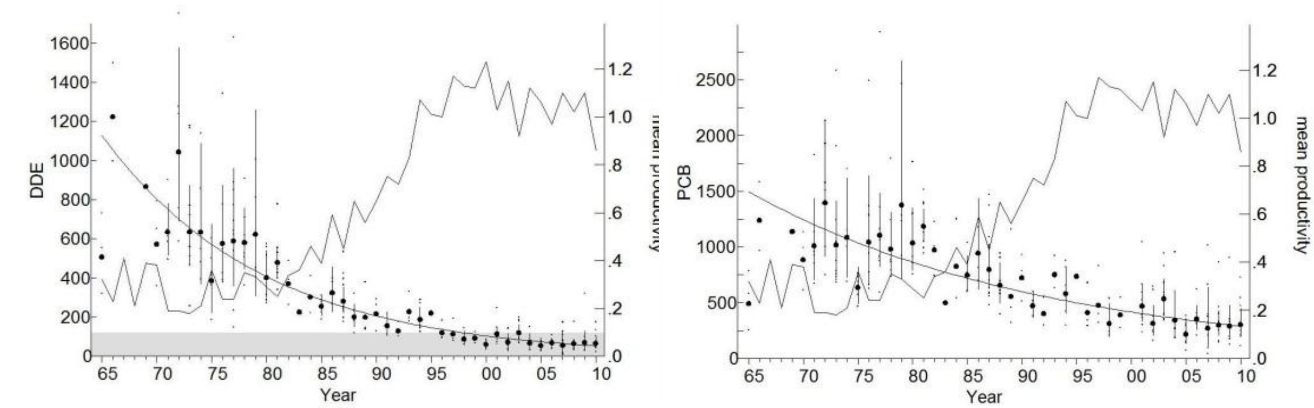

Figure 7. *Mean annual productivity (number of nestlings per checked occupied territory) and residue concentrations of DDE and total-PCB (µg/g, lipid.weight) in White-tailed eagle eggs from the Swedish Baltic coast 1965–2010. Shaded grey area in graph indicates a range of concentrations below a previously 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 the reference population in Lapland (not shown), there was no statistically significant change in*

Nutritional condition of nestlings

In theory, also effects of food shortage affect brood size, but this has so far not been observed in the Baltic population, where there has been, so far, plenty of food (Figure 8). Body mass can be indicative of food stress and health and is usually easily obtained when handling nestlings. An age-dependent increment in body mass naturally takes place in growing nestlings, and comparison of weights between nestlings must therefore be based on specimens of the same age. Wing length is strongly correlated to age in sea eagle nestlings (Helander 1981, Helander et al. 2007) and can be used as a proxy for age. A sub-sample (all nestlings available from 1977 to 1982) illustrates a considerable difference in weight between nestlings from the Swedish Baltic coast and from a population in Swedish Lapland (Figure 7). The Baltic coastal nestlings weighted more and did not seem to suffer from food shortage. Age-specific body mass data from nestlings can also be used to monitor trends in condition and health within a population.

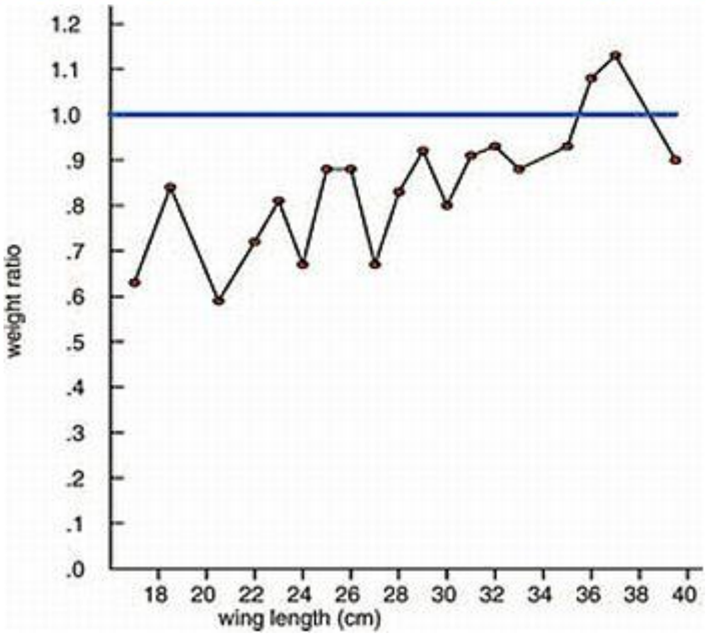

Figure 8. *Ratio between weights of nestlings of the same age from two white-tailed sea eagle populations in Sweden, based on 56 nestlings from Lapland (reference area) and 53 from the Baltic Sea coast (from Helander et al. 2008). Wing length in cm is used as a proxy for age according to Helander (1981). Wing length data in the graph was grouped into 19 intervals, and ratios are for Lapland/Baltic nestlings (the blue reference line at 1.0 reflects equal weight of nestlings of the same age in the two populations). The much thinner nestlings in Lapland within the wing length interval 16 – 28 cm (corresponding to approximately 3.5 – 5 weeks of age) was obviously a result of food stress that also lead to emaciation and death in many nestlings (Helander 1985).*

Other factors

The massive development of wind parks leads to a significant increase in mortality among breeders and can, in theory, be seen in a reduction in breeding success but not in brood sizes. It will also be possible to evaluate the influence on breeding success (and productivity) from the natural density dependent conflicts between eagle pairs. This was done in Germany (unpublished). Weather condition affects the breeding success, but with possible effects from climate change it will be of interest to follow.

Cause of death of deceased indiviruals

Eagles found dead in nature belong to the state in all countries around the Baltic Sea, except Germany. This provides good opportunities for investigations of the cause of death. In Sweden, state game is normally sent to the Swedish Museum of Natural History for registration, measurements, examination and preparation for the museum collections. 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 Sweden, organ samples are saved in the museum's Specimen Data Bank from all reasonably fresh specimens. Analyses of heavy metals in archived samples of sea eagle liver and kidney tissue have been carried out recently. The results for lead contamination revealed no decrease in lead concentrations over the period 1981 - 2004, and indicated that a minimum of 14% of investigated specimens were lethally poisoned from ingestion of lead ammunition (Helander et al. 2009). A follow-up study of lead in sea eagles from 2005 - 2010 will be undertaken in 2011 - 2012. Analyses of sea eagles found dead in Finland up till 2011 (death reasons, body condition, heavy metals, pesticides, parasitology, virology) will be conducted in a near future.

Metadata

Data source

Sweden: The National Swedish Monitoring Programme of Seas and Coastal areas/ National Environment Protection Agency; Swedish Museum of Natural History; Swedish Society for Nature Conservation (Project Sea Eagle).

Germany: Agency for Environment, Nature Conservation, and Geology of Mecklenburg-Western Pomerania

Finland: WWF Finland, Project Sea Eagle; Finnish Museum of Natural History.

Description of data

White-tailed sea eagle reproductive ability is monitored annually by assessing the frequency distribution of occupied eagle nests containing 0, 1, 2 or 3 nestlings (3 being the maximum in this species). Survey techniques and sampling methods are presented in (Helander 1994b, Helander et al. 2007, 2009). Three indicators of reproductive ability are calculated from these data: productivity, breeding success and nestling brood size. In addition, nutritional condition of nestlings is assessed. The productivity of the white-tailed sea eagle population was chosen as the core indicator to assess the status of the species. The data on brood size is substantially smaller, about half of the productivity data.

Sweden: Surveys of breeding populations and reproduction, sampling, sample preparation, storage in specimen bank and evaluation of results are carried out by the Department of Contaminant Research at the Swedish Museum of Natural History, Stockholm. Surveys of breeding populations and reproduction of reference freshwater populations are carried out by the Swedish Society for Nature Conservation (Project Sea Eagle), Stockholm. Chemical Analysis is carried out at the Institute of Applied Environmental Research at Stockholm University.

Germany: In Western Pomerania, data is collected by voluntary ornithologists, co-ordinated 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.

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

Geographic coverage

The results of this core indicator report cover Baltic coast and archipelagos between latitude 56 and 66 in Sweden, Baltic coast and archipelagos between latitude 62 and 64 and Åland archipelago in Finland, Baltic coast and inland of Mecklenburg-Western Pomerania in Germany.

Eagles are presently breeding along the coasts of the whole Baltic Sea, and are monitored in a network of national projects with harmonized methodology. Monitoring is made for the entire population. There are sub-regions with small subpopulations: the Gulf of Finland, and especially the Kattegat. See population abundance in HELCOM Baltic Sea Environment Fact Sheet for White-tailed eagle population and for sub-basins in Annex 1.

Temporal coverage

Results of this core indicator report are based on the following time series: Sweden 1964 – 2010, Finland 1965 – 2010, Germany 1973 – 2010.

Monitoring is done in the HELCOM Contracting Parties on the annual basis.

Recommendation for monitoring

Monitoring is considered adequate. See Annex 1 for details of the current monitoring.Temporal coverage

Single species assessments: all time series included.

Composite index: starts from 1991 with a virtual baseline year (weighted mean of the time period). The TRIM software requires either annual data or data at regular intervals

Methodology and frequency of data collection

Based on data from nests inspected by climbing the nest tree, and excluding nests checked only from the ground, nestling brood size is a precise standard. Nest trees are climbed for assessment of reproductive parameters. Some samples are taken from the ground (see below). In connection with these nest visits, measurements and biological samples are taken. The following parameters are measured from the nestlings: wing chord (for estimation of age in days), tarsus width and depth (for estimation of sex, see Helander 1981, Hauff & Wölfel 2002, Helander et al.2007), weight (for nutritional status) and feather and blood samples (for chemical analyses and genetic studies). The nestlings are ringed using an international colour ringing programme for identification, according to Helander (2003b). Dead eggs and shell pieces are collected for measurements, investigation of contents and chemical analyses, for studies on relationships with reproduction. Feathers shed from adults are collected at all sites. All samples are archived in the Swedish National Specimen Data Bank.

There is a sampling difference as regards the brood size observations. In Sweden, all nests are climbed to see the number of nestlings, whereas in Finland some data is checked from ground and in Germany the data from nests is only checked from the ground. This results in a certain error due to nestlings not visible from this position. However, this bias does not explain the full difference between the results. Data received from ground observations in Germany underestimated the real number of nestlings by 11 %. (Hauff & Wölfel 2002). Using this correction factor for the nests not climbed (about 50 % of the total German sample), the brood size was corrected for Mecklenburg-Western Pomerania.

Methodology of data analyses

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]).

Brood size

The mean number of nestlings of at least three weeks of age in nests containing young ([n1] + [n2x2] + [n3x3] / ([n1] + [n2] + [n3].

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]).

Simple log-linear regression analysis has been carried out to investigate average changes over time. To check for significant nonlinear trend components, a LOESS smoother was applied and an analysis of variance was used to check whether the smoother explained significantly more than the regression line. Statistical power analyses were used to estimate the minimum annual trend likely to be detected at a statistical power of 80 % during a monitoring period of 10 years. To investigate the possible effect of a future reduced sampling scheme, repeated random sampling (5000 times) from 1991 to 2006 in the current database was carried out, simulating a maximum of 50, 25, 20, 15, and 10 records each year. Contingency analysis, using the G-test with Williams correction, a log-likelihood ratio test, was applied for comparisons between geographical regions and time periods. For references see (Helander 2003a)..

Determination of GES boundary

The target for the core indicator (productivity) and for the supporting parameters, brood size and breeding success, are based on a Swedish data set during 1850s'-1954 (Figure 9). The reference condition was an average of the parameter values over that time period. The target applying to the good environmental status sensu EU Marine Strategy Framework Directive was set to the lower 95 % confidence limit of the observations during the reference period. The target is for breeding success 60 %, for brood size 1.64 nestlings and for productivity >1.0 nestlings. The observations should be measured as average of the last 5 years. These thresholds are based on data on the 15 km zone of the Swedish Baltic coast (Helander 1981). 15 km has been widely observed to be the range for foraging among white-tailed sea eagles. The applicability of the targets to other parts of the Baltic Sea should be validated.

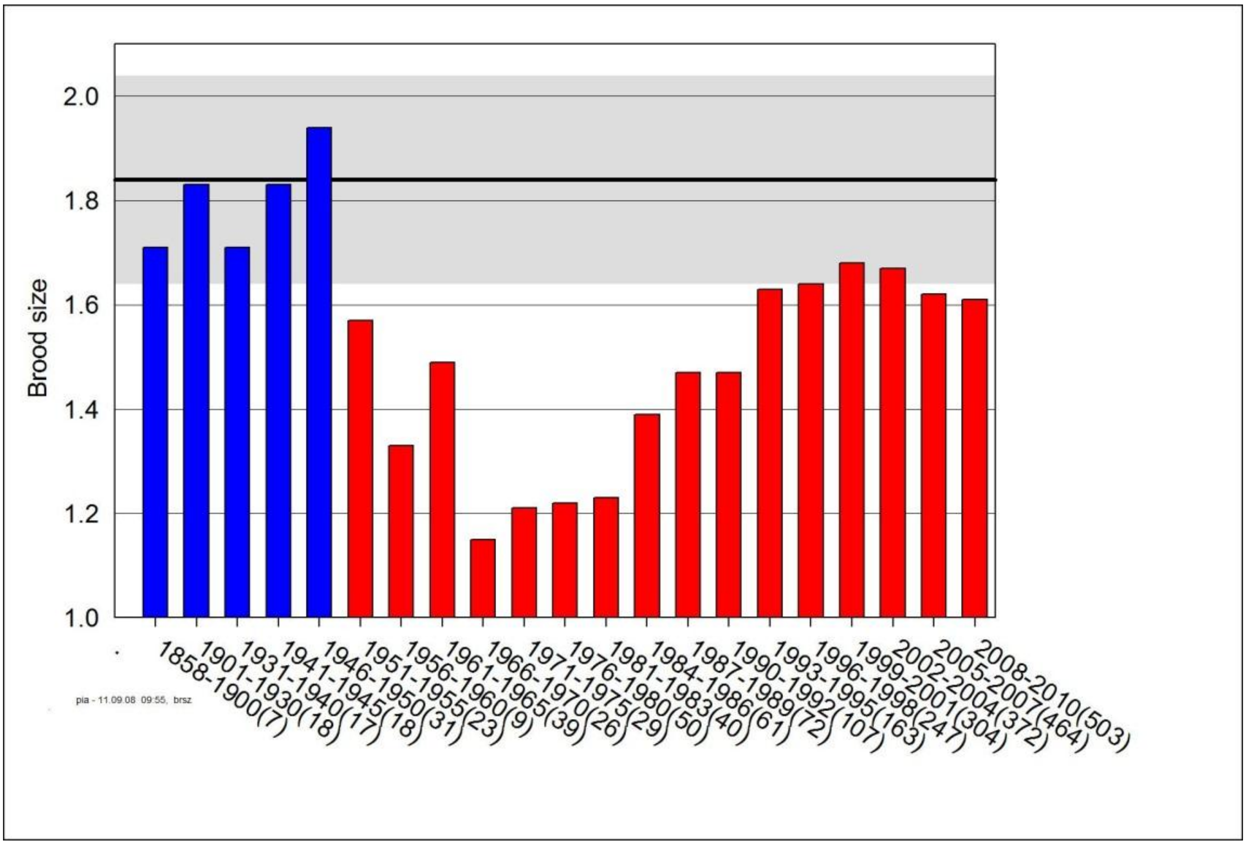

Figure 9. *Mean brood size (number of nestlings per successfully breeding pair) of white-tailed sea eagle on the Swedish Baltic coast since 1858. Sample size for each time period is given in brackets. A reference level (solid black line) with 95% confidence limits (shaded grey) is based on data between 1858–1950 (blue bars) according to (Helander 2003a).*

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 (Hauff 2009). Minimum detectable trends based on the raw data set 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 with the only differences being whether to climb to the nest or survey it from the ground (applying the conversion factor).

Quality of information

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 data set between 1991– 2006 (with a varying annual n 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).

Further work required

Reliability of the core indicator can be increased by continuing to develop the target levels and further studying their linkage to anthropogenic pressures, such as disturbance in the vicinity of nests, wind farms and contaminants.

The core indicator lacks currently data from several Contracting Parties.

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Annex 1

Data table 1. *A specification of the applicability of the indicator in different parts of the Baltic Sea.*

	Gulf of Bothnia (FIN, SWE)	**Åland Sea + Archipelago Sea (FIN, SWE)**	**Gulf of Finland (EST, FIN, RUS)**	**Northern & Central Baltic Proper + Gulf of Riga (EST, LAT, LIT, SWE)**	**Southern Baltic Proper (GER, LIT, POL, RUS, SWE)**	**Danish Straits and German Bights (DEN, GER, SWE)**	**Kattegat+ Limfjorden (DEN, SWE)**
Top predator of MARINE food web: YES/PARTLY/NOT/ UNCERTAIN	YES FIN ~90 pairs SWE ~60 pairs ***Sum 150***	YES FIN ~210 pairs SWE ~60 pairs ***Sum 260***	YES EST 22-25 pairs FIN ~30 pairs RUS 6 pairs ***Sum ~60***	YES EST 150-165 pairs LAT 20-30 pairs LIT no coastal pop SWE ~200 pairs ***Sum ~380***	YES/PARTLY*(=incl lagoons) GER 120 pairs* LIT ~ 10 pairs* POL ~50 pairs* SWE 10 pairs ***Sum 190***	PARTLY DEN – 26 pairs (GER no coastal pop) (SWE no pop.) ***Sum 26***	UNCERTAIN DEN – 8 pairs (SWE no pop.) ***Sum 8***
Mark the main prey species or species groups	FIN - Fish 34%,water fowl 55%, mammals 11% (incl. carrion)	FIN - Fish 28%, water fowl 66% other 6% (incl. carrion) SWE - Fish 36%, water fowl 58% other 8% (incl. carrion)	EST - Fish & waterfowl, seals (carrion) RUS - Fish & water birds, perhaps seals (carrion)	EST & LAT - Fish & waterfowl, seals (carrion) LIT no coastal pop SWE - Fish 36%, water fowl 58% other 8% (incl. carrion)	GER - Fish, waterfowl, geese, carcasses (e.g. deer, wild boars) LIT mainly fish SWE - Fish & waterfowl, carrion	DEN – fish, waterfowl, geese, carrion	DEN - waterfowl, geese, carrion
Productivity is affected by pollutants: YES/PARTLY/NOT/UNCERTAIN	SWE – PARTLY FIN - UNCERTAIN	SWE – YES FIN - PARTLY	EST – YES (?) RUS - UNCERTAIN	EST – YES (?) LAT – UNCERTAIN LIT no coastal pop	GER - No indication; has increased and stabilized probably on pre-	DEN - NO	DEN - NO

				SWE - NO	DDT-level' LIT – UNCERTAIN POL & SWE - NO		
Does monitoring exist? (mark country)	FIN, SWE	FIN, SWE	EST, FIN, RUS	EST, LAT, (LIT), SWE	GER, LIT, POL, RUS, SWE	DEN, GER, SWE	DEN (barely present on W coast of SWE)
How dense monitoring is required (spatially)? (1) ***See comment 1 below***	FIN & SWE Whole popsince 1960s/1970s	FIN & SWE Whole popsince 1960s/1970s	EST & FIN & RUS - Whole population	EST - whole pop although from year 2014 we will monitor at least 50% nests per year LAT – Whole pop LIT – Whole pop SWE - Whole pop since 1960s/1970s	GER -Full coverage monitoring LIT - Whole pop SWE Whole pop. since resettlement in the 1990s	DEN - whole pop	DEN - whole pop
How frequent monitoring is required? (2) ***See comment 2 below***	FIN & SWE Annual since 1960s/1970s	FIN & SWE Annual since 1960s/1970s	EST & FIN & RUS Annual	SWE Annual since 1960s/1970s	GER, LIT, POL,SWE Annual	DEN Annual	DEN Annual

(1) **Comment**:

From the indicator point of view: could the monitoring focus on some smaller areas or does it require the whole population on the coastal strip?

Whole-population data will be necessary to identify local and regional problems. If restricted to sampling areas, we may well have missed to detect the serious, deviating situation in parts of the Gulf of Bothnia in Sweden. Sea eagles are naturally not very common, and when possible, full-scale monitoring of breeding pairs is recommendable to obtain useful data sets. Most ongoing national monitoring of sea eagles within the Helcom region is currently on a whole-population basis.

The population of sea eagles on the Swedish coastline has increased from about 30 to 300 pairs between 1965 and 2012. The whole population is still included in our national monitoring program, but if the increase continues it may be necessary to limit the effort. Where to draw the line will of course depend on the desired precision to detect a trend/difference at a specified statistical power. The difference in estimated detectable trends at a statistical power of 80 % with varying sample sizes of sea eagle reproductive parameters is presented in Ambio vol. 37(6), 425-431 (2009)

A restricted effort could be built on selected intensive sampling areas, spread over the distribution range (leaving out breeding pairs in-between), or be built on selected (traditional) territories more or less evenly distributed over the distribution range (thus keeping up the full geographical scale), or perhaps a combination of both approaches. For most countries within the Helcom range, though, populations are still too small to be handled that way, whole-population monitoring should be the case.

(2) Comment:

From the indicator point of view: could the monitoring be performed at greater intervals than annually?

As above, this depends on the desired outputs. Greater intervals are not desirable - annual monitoring yields the most solid basis for assessments, and so is clearly to prefer. See also the paper "The need for proper sampling…."

As above, most ongoing national monitoring of sea eagles within the Helcom region is currently on a yearly basis. As long as this situation can be maintained it would be a waste not to collect the data annually.