Name of indicator	3.10 Zooplankton mean size vs. total stock (MSTS)
Type of Indicator	State indicator
Author(s)	Elena Gorokhova, Maiju Lehtiniemi, Jurate Lesutiene, Solvita Strake, Laura Uusitalo, Natalja Demereckiene, Callis Amid
Description of the indicator	The indicator is based on the idea that the mean size of zooplankton and the biomass or abundance, when examined together, provide more information than when the parameters are considered separately. Abundant zooplankton with a high mean size would indicate good feeding conditions for zooplanktivorous fish as well as high potential grazing on phytoplankton; while other combinations (small total stock, or small mean size, or both) would indicate limitations in the ability of the zooplankton community to transfer energy from primary producers to higher trophic levels (HELCOM 2013, Gorokhova *et al*. in prep.).

The data for the indicator is obtained through routine zooplankton monitoring programs carried out in several Baltic Sea countries. Annual (once a year) sampling provides sufficient data for the calculation of the indicator, but a higher sampling frequency would probably be better due to decreasing the variation in the data. There is no minimum requirement for the taxonomic resolution in the sample analysis because the only required data is the number of individuals and the size of the individuals.

The indicator has a solid scientific basis and it addresses the importance of zooplankton as the mediator of energy from primary producers to fish. However, the inherent noise in zooplankton data presents a challenge in setting the GES boundaries, as well as evaluating the indicator values from year to year. |
| Relationship of the indicator to marine biodiversity | The indicator reflects changes in the zooplankton community. These changes are indirectly related to changes in nutrient composition and directly related to fish communities, climate and phytoplankton community composition, and have direct impact on both phytoplankton communities and fish growth.

Zooplankton has a crucial role in the pelagic food web dynamics: it transfers energy from primary producers to a form utilizable by fish. Zooplankton is affected by changes in primary production, indicative of eutrophication, and by changes in the structure and abundance of the fish community, indicative of overfishing (e.g. Adrian *et al*. 1999, Yan *et al*. 2008). Therefore, zooplankton lives between top-down and bottom-up dynamics, and can potentially yield a lot of information on the state and dynamics of the aquatic ecosystem (Jeppesen *et al*. 2011). Zooplankters are selective feeders. Some species eating solely herbivorously or carnivorously but many of the species are omnivorous utilising both phytoplankton and zooplankton species as prey. The size of zooplankters affects their prey selection. Thus the species composition in the zooplankton community affects directly both the phytoplankton and zooplankton species composition through size-selective feeding and have a potential to affect the biodiversity in these communities. |
| Relevance of the indicator to different policy instruments | Through collaboration between MARMONI and the HELCOM CORESET project. The indicator has been listed as a Core Indicator in the HELCOM CORESET of Biodiversity indicators (HELCOM 2013.

Marine Strategy Framework Directive (MSFD) descriptors 1 Biodiversity, 4 Food webs. HELCOM Baltic Sea Action Plan. |
| Relevance to commission decision criteria and indicator | 1.2. Population size
1.2.1. Population abundance and/or biomass
1.3. Population condition
1.3.1. Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates)
1.6. Habitat condition
1.6.1. Condition of the typical species and communities |
| Method(s) for obtaining indicator values | The indicator is based on zooplankton data obtained from routine zooplankton sampling (e.g. HELCOM COMBINE; HELCOM 1988). The total stock (indicated as either biomass or abundance) means the number of zooplankton individuals. Abundance is determined by light microscopy, either by traditional "manual" counting, or by an automatic image analysis method using a scanner and suitable software. Biomass can be estimated based on length measurements of individuals (automatic image analysis does this), or by using species and stages specific pre-established weight values (if sample analysis is done with 'manual' counting by a microscope). The mean size of the zooplankton community is calculated by dividing the biomass of the whole community by the number of zooplankton individuals. The indicator is based on the combination of these two values (total stock and mean size). |
| Documentation of relationship between indicator | Zooplankton biomass correlates positively with phytoplankton biomass and hence with eutrophication; in particular, small-bodied, filter-feeding (microphagous) zooplankters increase with increasing eutrophication (Gliwicz 1969, Pace 1986, Hsieh *et al*. 2011). On the |

and pressure	other hand, the large-bodied zooplankters, especially copepods, constitute the best-quality food items for the zooplanktivorous fish (e.g. Cardinale *et al*. 2002, Rönkkönen *et al*. 2004). Rönkkönen *et al.* (2004) reported that in the Gulf of Finland, herring growth correlates positively with the abundance of the marine zooplankton species *Pseudocalanus minutus elongatus*.
Geographical relevance of indicator	4. Baltic Sea wide
How Reference Conditions (target values/thresholds) for the indicator were obtained?	Good Environmental Status is based on a reference period within existing time series that defines a reference state when the food web structure was not measurably affected by eutrophication and/or representing good fish feeding conditions. The reference period for the zooplankton indicator was selected when 1. GES for chlorophyll *a* concentrations and water transparency, that have been specifically defined for the sub-basins of the Baltic Sea (HELCOM 2009), were in GES, and 2. Growth of zooplanktivorous fish (weight-at-age, WAA) and population size were relatively high. Recently, Ljunggren *et al*. (2010) have demonstrated that WAA could be used as a proxy for zooplankton food availability and related fish feeding conditions to fish recruitment in coastal areas of the northern and central Baltic Sea. GES boundaries are set region-specifically (e.g. Gulf of Finland, Gulf of Riga, Gulf of Bothnia etc.).
Method for determining GES	GES is met when – there is a high contribution of large-sized individuals (mostly copepods) in the zooplankton community that efficiently graze on phytoplankton and provide good-quality food for zooplanktivorous fish, and – the abundance of zooplankton is at the level adequate to support fish growth and exert control over phytoplankton production. GES will be determined for two parameters: the zooplankter mean size and the total abundance or biomass of the zooplankton community (Fig. 1). - The reference period for the mean size: the GES boundary is at lower 95% CI of the mean during a time period when zooplankton is adequate to support high growth of zooplanktivorous fish (measured as weight at age [WAA] and high stock size). The high WAA values in combination with relatively high stock abundance (to avoid density-dependent WAA) indicate good growth of the herring stock because of high abundance of high-quality food (usually large amount of copepods) and, thus, a good reference period with regard to the fish-feeding conditions. - The reference period for the total zooplankton abundance (or biomass) reflects a time period when effects of eutrophication are low, defined as 'acceptable' chlorophyll a concentration (i.e. EQR > 1) and hence eutrophication-related food web changes are negligible. - The obtained values (mean size and total zooplankton abundance) are placed to the schematic 4-square (Fig. 1), where the areas of the diagram get values from 1 to 3 (lower left corner = 1 = below GES, upper left and lower right corners = 2 = below GES and upper right corner = 3 = GES). Thus if both mean size and total zooplankton abundance values settle to the upper right corner, the GES is met and the indicator value is 3. GES-boundaries for the open Gulf of Finland (MARMONI 4FIN-EST area) are >0.0063 mg for the mean size and >9080 ind/m^3 for total abundance, indicator value is 3. The status for the assessment period 2010-2012 for this area is below GES, indicator value is 2 (mean size = 0.0056 mg and total abundance= 32671 ind/m3). The reference periods considered were 1979-1982 for mean size and 1979-1987 for total abundance. GES-boundaries for the Gulf of Riga (MARMONI 1EST-LAT area) are >0.0027 mg/ind for the mean size and >91722 ind/m^3 for total abundance, indicator value is 3.The status for the assessment period 2010-1012 for this area is below GES, indicator value is 2 (mean size = 0.0036 mg/ind and total abundance = 83853 ind/m^3). The reference periods considered were 1993-1997 for mean size and 1995-1999 for total abundance.
References	Adrian, R., Hansson, S., Sandin, B., DeStasio, B., Larsson, U. (1999) Effects of food availability and predation on a marine zooplankton community—a study on copepods in the

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Baltic Sea. Int Rev Hydrobiol 84:609–626

Cardinale, M., Casini, M., Arrhenius, F. (2002) The influence of biotic and abiotic factors on the growth of sprat (*Sprattus sprattus*) in the Baltic Sea. Aquat. Liv. Res.: 273-281.

Gliwicz, Z.M. (1969) Studies on the feeding of pelagic zooplankton in lakes with varying trophy. Ekol. Pol., 17, 663–708.

HELCOM (1988) Guidelines for the Baltic monitoring programme for the third stage. Part D. Biological determinants. Baltic Sea Environment Proceedings 27D: 1-161.

HELCOM (2013) MSTS indicator description sheet. Available at the HELCOM web site: http://meeting.helcom.fi/c/document_library/get_file?p_l_id=80219&folderId=2289395&name=DLFE-54128.docx

Hsieh CH, *et a.l* (2011) Eutrophication and warming effects on long-term variation of zooplankton in Lake Biwa. Biogeosciences 8: 593-629.

Jeppesen E, *et al.* (2011) Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). Hydrobiologia 676: 279-297.
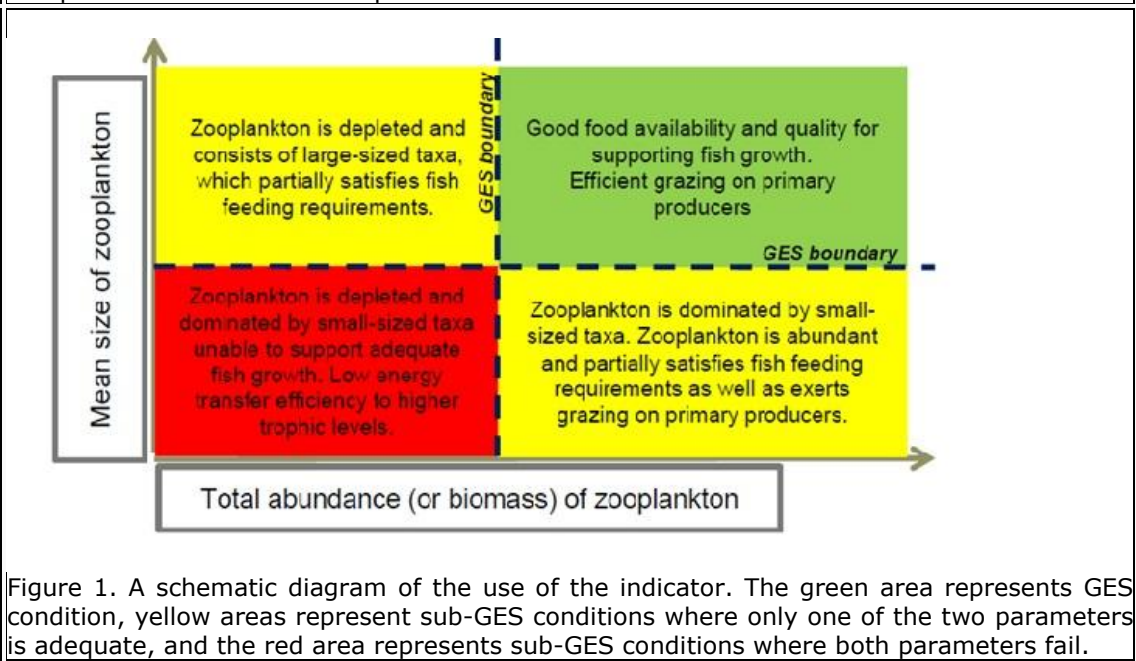
Ljunggren, L., Sandström, A., Bergström, U., Mattila, J., Lappalainen, A., Johansson, G., Sundblad, G., Casini, M., Kaljuste, O., and Eriksson, B. K. 2010. Recruitment failure of coastal predatory fish in the Baltic Sea coincident with an offshore ecosystem regime shift. ICES Journal of Marine Science, 67: 1587-1595.

Pace, M.L. 1986. An empirical analysis of zooplankton community size structure across lake trophic gradients. Limnol. Oceanogr. 31: 45-55.

Rönkkönen S, Ojaveer E, Raid T, Viitasalo M (2004) Long-term changes in Baltic herring (*Clupea harengus membras*) growth in the Gulf of Finland. Canadian Journal of Fisheries and Aquatic Sciences 61: 219-229.

Yan ND, *et al*. (2008) Long-term trends in zooplankton of Dorset, Ontario, lakes: the probable interactive effects of changes in pH, total phosphorus, dissolved organic carbon, and predators. Can. J. Fish. Aquat. Sci. 65: 862-877.

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Illustrative material for indicator documentation

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Figure 1. A schematic diagram of the use of the indicator. The green area represents GES condition, yellow areas represent sub-GES conditions where only one of the two parameters is adequate, and the red area represents sub-GES conditions where both parameters fail.

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4 Bird indicators

Name of indicator	4.1 Abundance index of wintering waterbird species
Type of Indicator	State indicator
Author(s)	Ainars Auniņš, Leif Nilsson, Andres Kuresoo, Leho Luigujõe, Antra Stīpniece

Description of the indicator	This is a single species indicator and it reflects population level at wintering season of the particular species compared to reference level (population at base year or period). Index is calculated for all species that are regularly recorded at inshore and offshore areas of the Baltic Sea during wintering period. Indicator is calculated separately for inshore and offshore areas due to different data collection schemes. Baltic-wide indicators are calculated separately for each of the following species: *Cygnus olor, Cygnus cygnus, Fulica atra, Anas platyrhynchos, Clangula hyemalis, Melanitta nigra, Melanitta fusca, Somateria mollissima, Aythya marila, Aythya fuligula, Bucephala clangula, Aythya ferina, Mergus albellus, Gavia stellata, Gavia arctica, Mergus merganser, Mergus serrator, Podiceps cristatus, Alca torda, Uria aalge, Cepphus grylle, Larus minutus, Larus ridibundus, Larus canus, Larus argentatus, Larus marinus*. Species lists for national and subbasin versions of these indicators are country and subbasin specific.
Relationship of the indicator to marine biodiversity	The indicator reflects status of important components of the marine biodiversity. This indicator (population indices for each species) is further used for calculation of other indicators (e.g. Wintering waterbird index)
Relevance of the indicator to different policy instruments	MSFD descriptors 1 (species level/population size and habitat level/condition of typical species) and 4 (abundance trends of functionally important selected species). Habitats Directive (this indicator is needed for Article 17 reporting to report status of typical species of the habitat types 1110 and 1170; Anon 2007, Aunins 2010) Birds Directive (this indicator is needed for Article 12 reporting to report long-term and short-term population trend of all regularly occurring wintering marine waterbird species. HELCOM CORESET (in collaboration with MARMONI an inshore part of this indicator developed using inshore data collected during International Waterbird Census)
Relevance to commission decision criteria and indicator	1.2. Population size 1.2.1. Population abundance and/or biomass 1.6.1. Condition of the typical species and communities
Method(s) for obtaining indicator values	Field data collection: using any of the standard methods. For inshore part of the indicator coastal ground counts (such as International Waterbird Census; methods described in Wetlands International 2010) are used. This type of data has been collected in all Baltic Sea countries for decades. Data for offshore part of the indicator need to be collected using ships or planes (Komdeur *et al.* 1992, Petersen *et al.* 2005, Camphuisen *et al*. 2006, Nilsson 2012). Indicator calculation: The index gives species population abundance relative to population at base time (period). Average wintering population during 1991 - 2000 period is suggested as base level. To obtain the population index, site and year specific counts of individuals of particular species are related to site and year effects (factors) and missing values are imputed from the data of all surveyed sites. Freeware programme TRIM is available to produce annual indices based on loglinear models (Pannekoek & van Strien 1998). In addition to annual indices, TRIM allows the estimation of trends over the whole period. To separate true time effects from other impacts such as climate change, using models that include climate specific covariate has been suggested (Aunins *et al*. in prep). The suggested model includes mean air temperature during the week preceding bird counts as a covariate in addition to site and year and used GAM (generalised additive modelling) framework. The model accounts for serial correlation and overdispersion.
Documentation of relationship between indicator and pressure	Each of the species for which the indicator is calculated respond to different pressures. Important pressures and response patterns vary among the species. The indicator (depending on species) responds to: eutrophication oil pollution/shipping hazardous substances fishing pressure bycatch hunting fisheries discards coastal development

|	wind energy
	sand and gravel extraction
	climate change
	Latest knowledge and summary of related studies are given in Skov *et al.* 2011
	Contribution of each particular pressure on a given species can be controlled by including additional explanatory variables characterising the level of the pressure as covariates in the indicator calculation model.
Geographical relevance of indicator	2. Regional 3. National waters 4. Baltic Sea wide
How Reference Conditions (target values/ thresholds) for the indicator were obtained?	Reference conditions (GES thresholds) are set at 30% on both sides from base population level (i.e. mean population during 1991 - 2000 period). Thus indicator for each particular species can be considered being at GES if it falls between 70 and 130% (ICES 2013).
Method for determining GES	Currently GES levels have been set arbitrarily at 30% on both sides from base population level (i.e. mean population during 1991 - 2000 period). More ecological studies are needed to set species specific GES thresholds as well as to choose different and species specific time periods reflecting base population levels.
References	Anon. 2007. Interpretation manual of European Union Habitats. EUR 27. European Commission DG Environment. Aunins A. (ed.) 2010. [Protected habitats of European Union in Latvia. Identification Handbook]. Latvian Fund for Nature, Riga, 320 pp. Aunins A., Clausen P., Dagys M., Garthe S., Grishanov G., Korpinen S., Kuresoo A., Lehikoinen A., Luigujoe L., Meissner W., Mikkola-Roos M., Nilsson L., Petersen I.K., Stipniece A., Wahl J. (in prep) Development of Wintering Waterbird Indicators for the Baltic Sea. Camphuysen C.J., Fox A.D., Leopold M.F. & Petersen I.K. 2004. Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K.. Report commissioned by COWRIE for the Crown Estate, London. Royal Netherlands Institute for Sea Research, Texel, 38 pp. ICES. 2013. Report of the Joint ICES/OSPAR Ad hoc Group on Seabird Ecology (AGSE), 28-29 November 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:82, 30 pp. Komdeur, J., Bertelsen, J. & Cracknell, G. (Eds.). 1992. Manual for Aeroplane and Ship Surveys of Waterfowl and Seabirds. IWRB Special Publication No. 1, Slimbridge, UK, 37 p. Nilsson, L. 2012. Distribution and numbers of wintering sea ducks in Swedish offshore waters. Ornis Svecica 22: 39-60. Petersen, I.K, Fox, A.D. 2005. An aerial survey technique for sampling and mapping distributions of waterbirds at sea. Department of Wildlife Ecology and Biodiversity, National Environmental Research Institute. 24 pp. Skov. H., Heinänen S., Žydelis R., Bellebaum J., Bzoma S., Dagys M., Durinck J., Garthe S., Grishanov G., Hario M., Kieckbusch J.J., Kube J., Kuresoo A., Larsson K., Luigujõe L., Meissner W., Nehls H.W., Nilsson L., Petersen I.K., Roos M.M., Pihl S., Sonntag N., Stock A., Stipniece A., Wahl J. 2011. Waterbird Populations and Pressures in the Baltic Sea. Nordic Council of Ministers, Copenhagen, 201 pp. Van Strien, A.J., Pannekoek, J. et Gibbons, D.W. (2001): Indexing European bird population trends using results of national monitoring schemes: a trial of a new method. Bird Study 48: 200-213. Wetlands International 2010. Guidance on waterbird monitoring methodology: Field Protocol for waterbird counting. Report prepared by Wetlands International.
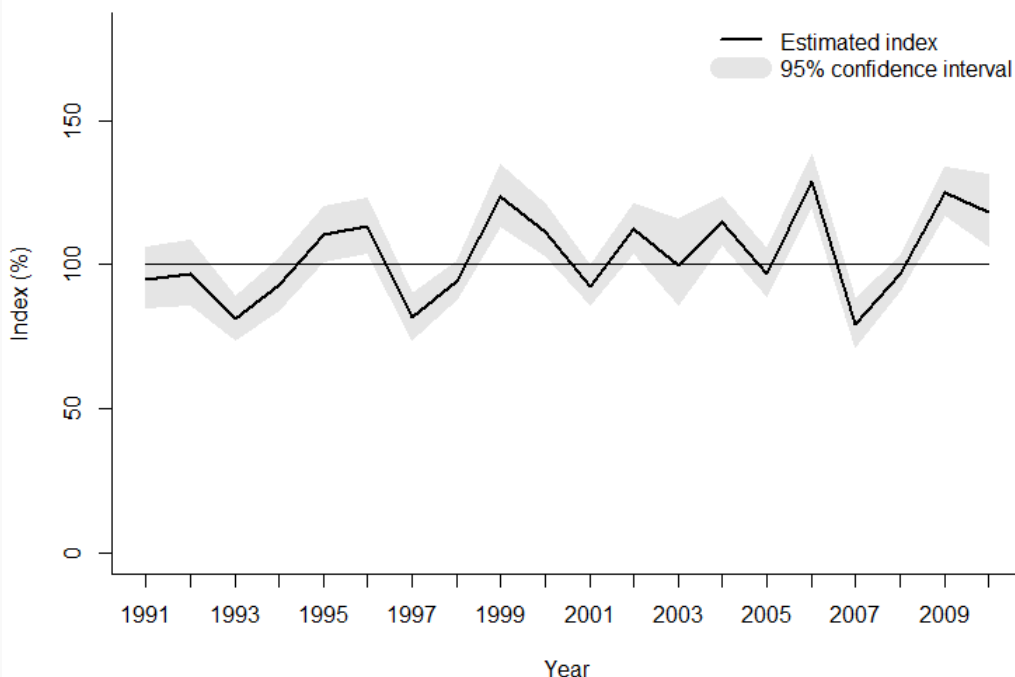
Figure 1. Example draft indicator for inshore part of the Baltic sea (currently only data from Sweden, Estonia, Latvia, Lithuania, Poland (only Gulf of Gdansk) and Germany used): Goldeneye *Bucephala clangula*
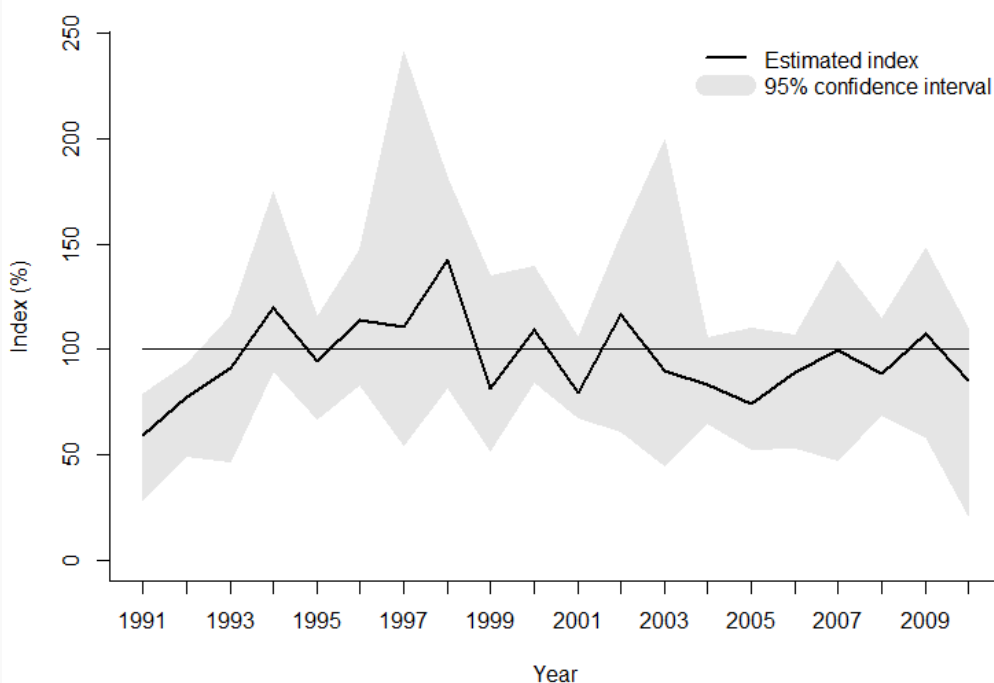

Figure 2. Example draft indicator for inshore part of the Baltic sea (currently only data from Sweden, Estonia, Latvia, Lithuania, Poland (only Gulf of Gdansk) and Germany used): Common Eider *Somateria mollissima*