Trends in the abundance of diving ducks and seaducks wintering in Japan

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Abstract

Japan is an important wintering area for many Asian diving duck and seaduck populations, although their status and trends in abundance are poorly known and previously undescribed. Trends in annual abundance therefore were analysed for nine common diving and seaduck species wintering in the country, using data from the national waterbird surveys undertaken annually by volunteers and coordinated by the Ministry of the Environment and local prefectures over the past 46 years. Annual indices and short-term (16 years: 2000–2015), medium-term (26 years: 1990–2015) and long-term (36 years and 46 years to 2015) trends in numbers were calculated for each species using TRIM software. The indices recorded for Long-tailed Duck *Clangula hyemalis*, Harlequin Duck *Histrionicus histrionicus*, Black Scoter *Melanitta americana* and Red-breasted Merganser *Mergus serrator* all exhibited significant long-term declines; Common Goldeneye *Bucephala clangula* and Common Pochard *Aythya ferina* showed moderate declines over the 26-year period; and Greater Scaup *A. marila* declined during 2000–2015. Numbers of Tufted Duck *A. fuligula* increased significantly over 36- and 26-year time-scales, but it was found to be "stable" over the most recent 16 years. Velvet Scoters *Melanitta fusca* have tended to decrease since their peak abundance in 1977, although TRIM's criteria indicated that the trend was "uncertain".

Key words: diving ducks, Japan, long-term trends, seaducks, TRIM.

Long-term and large-scale monitoring of wildlife can provide valuable information on population status and/or habitat conditions for different species. The conservation status of the world's waterbird populations is based on an assessment of their abundance and trends in the main biogeographic regions and flyways (Wetlands International 2012).

Furthermore, information on habitat and resource use has also been collated together with the data on bird numbers and distribution recorded in Europe and North America over several decades (*e.g.* Davis *et al.* 2014). Yet despite the fact that Asia has 93 Ramsar sites and nine World Heritage sites (Li *et al.* 2009), and supports the largest proportion of the world's waterbird populations, the proportion of flyway populations for which no estimate of numerical abundance exists remains high in this region, while *c.* 50% of all Asian waterbird populations for which trends are available are considered to be in decline (Wetlands International 2012).

In Japan, the Ministry of the Environment has been coordinating wintering waterbird surveys in cooperation with prefectural and city governments since 1970 (Ministry of the Environment 2014). These long-term and large-scale data have been used to analyse the relationships between habitat characteristics and waterfowl abundance, but mainly for dabbling ducks *Anas* sp. (Asama & Yamashiro 1987; Higuchi *et al.* 1988; Kasahara & Koyama 2010). The status of the 22 species of diving ducks and seaducks (*Aythya, Polystica, Somateria, Histrionicus, Melanitta, Clangula, Bucephala, Mergellus* and *Mergus* sp.) that occur in Japan still generally remains unknown and unreported.

This paper therefore aims to analyse the long-term monitoring data collected from all 47 prefectures in Japan to estimate trends in the abundance of diving duck and seaduck species wintering in the country. Variation in the trends over different time-periods are also determined, and possible reasons for the trends are discussed.

Methods

Waterbirds wintering in Japan have been counted at thousands of sites in mid-January each year since 1970, for a national monitoring programme of these species with, for example, a total of 8,984 sites surveyed in January 2014 (Ministry of the Environment 2014; Fig. 1). In principle, the count sites included the numerically most important wintering sites for waterbirds, determined on the basis of data collected in previous years and from information provided by conservation groups. Volunteer bird-watchers, including hunting groups and the staff of national wildlife protection areas, were assigned to collect data at each site, covering coastal areas, estuaries, rivers, natural lakes and artificial waterbodies. Counts of coastal areas were limited in that the observations were made from the shore, so birds beyond the range of binoculars and telescopes would not have been sighted. At every site covered by the monitoring programme, however, each species of waterbird was identified, its numbers counted and the habitat was also recorded. The data were then submitted to and compiled by the Ministry of the Environment (Ministry of the Environment 2014).

We selected nine common diving and seaduck species for this analysis, on the basis that near-annual count data were available but long-term trends in their numbers wintering in Japan had not previously been assessed: Common Pochard *Aythya ferina*, Tufted Duck *A. fuligula*, Greater Scaup *A. marila*, Harlequin Duck *Histrionicus*

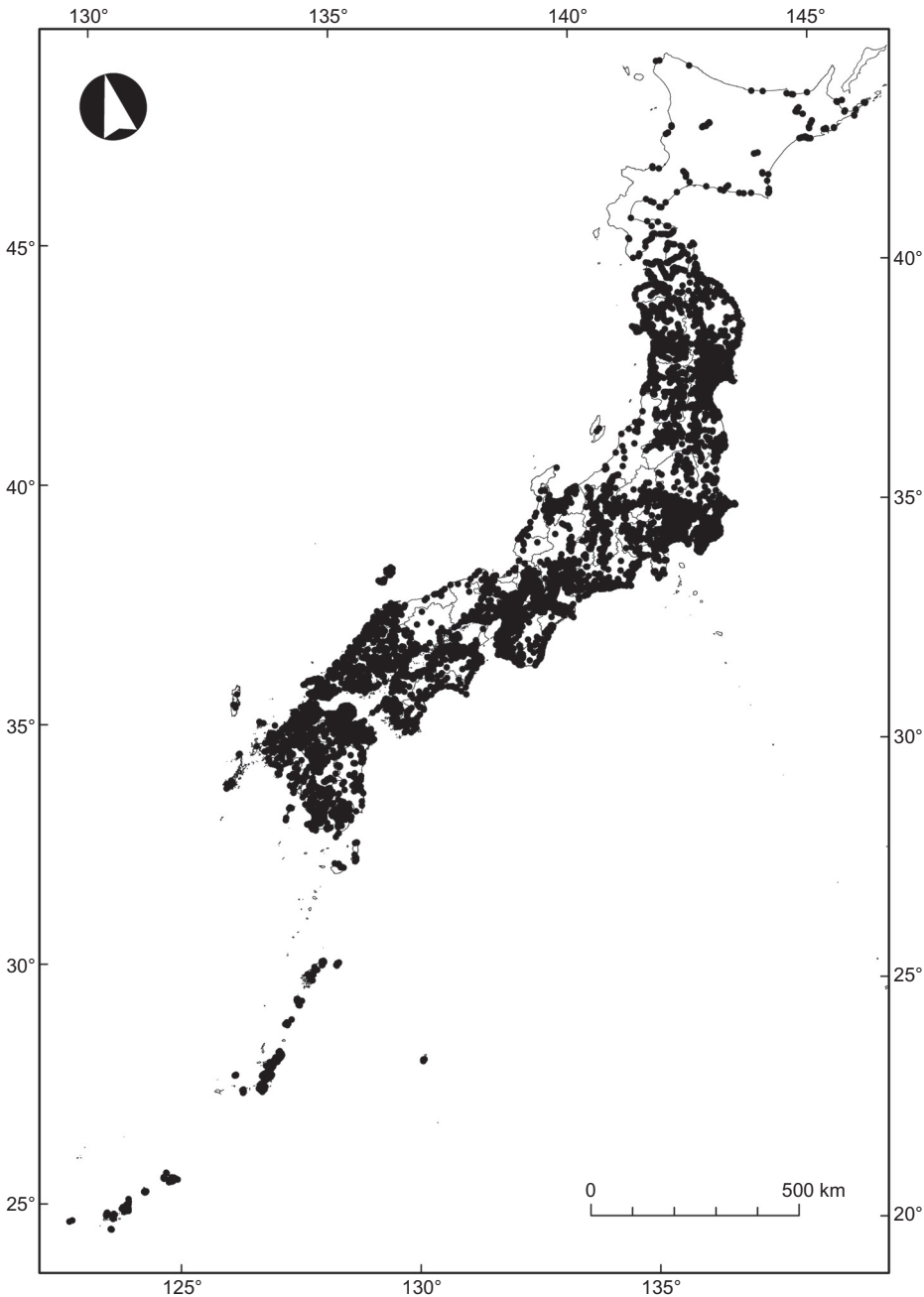

Figure 1. All waterbird count sites in Japan, including those where diving ducks or seaducks were recorded (based on data from the Ministry of the Environment 2014).

histrionicus, Velvet Scoter *Melanitta fusca*, Black Scoter *M. americana*, Long-tailed Duck *Clangula hyemalis*, Common Goldeneye *Bucephala clangula* and Red-breasted Merganser *Mergus serrator* (The Ornithological Society of Japan 2012). Of these nine species, some Harlequin Ducks breed in mountain streams in northern Japan, but the others are all winter visitors.

Count data were compiled from all 47 prefectures in Japan, irrespective of whether or not they had a sea coast. Common Pochard, Tufted Duck and Common Goldeneye occurred not only at coastal sites but also at inland wetlands (Nakamura & Nakamura 1995); trends of abundance for these three duck species therefore were analysed using data from all prefectures. The other six duck species occurred exclusively at coastal sites (Nakamura & Nakamura 1995), so trends in their abundance were estimated using data from the 39 prefectures with a coast-line. Trends in abundance and annual indices were calculated using the freeware programme TRIM version 3.53 (Pannekoek & van Strien 2001), developed for the analysis of wildlife count data, for four different time-spans: over 16 years (2000–2015), 26 years (1990–2015), 36 years (1980–2015) and 46 years (1970–2015). Long-term trends (*i.e.* for the whole time period) were determined from multiplicative trends, which reflect the mean percentage change per year (Pannekoek & van Strien 2001). We present the annual change in indices for each species in the results.

Results

Annual changes, standard errors (s.e.) and long-term population trends for each duck population are summarised in Table 1 and Fig. 2. The population indices showed a significant decrease for four species (Long-tailed Duck, Harlequin Duck, Black Scoter and Red-breasted Merganser) and an increase for two species (Common Pochard and Greater Scaup) between 1970 and 2015, with trends for Common Goldeneye, Tufted Duck and Velvet Scoter being "stable" or "uncertain" over this long (46-year) time-scale. Analysis of more recent trends found however that the Common Goldeneye (which had been "stable" in the longer term) and Common Pochard ("moderately increasing" in the longer term) have undergone a "moderate decline" over the past 26 years. Most recently, in 2000–2015, the Greater Scaup, which had been "moderately increasing" or "stable", has gone into decline, and the Long-tailed Duck and Harlequin Duck are now considered by TRIM classification to be in "steep decline". The Tufted Duck, which increased significantly in numbers in the 1980s and 1990s (*i.e.* over the 36- and 26-year periods) was assessed as being "stable" over the past 16 years (Table 1). Velvet Scoters have tended to decrease since their peak abundance in 1977 (Fig. 2), although the trend has been classified as "uncertain" by the TRIM analysis.

The annual rates of change suggest that the most rapid declines were over recent (2000–2015) years for Harlequin Duck (–8.71%), Long-tailed Duck (–23.48%), Red-breasted Merganser (–3.94%), Common Pochard (–3.43%) and Greater Scaup (–2.61%). For Black Scoter and Common Goldeneye the annual declines (–3.20% and –0.84% respectively) were

Table 1. Annual percentage changes (with estimated s.e. in parentheses) of population indices and long-term trends (1970–2015), over the past 36, 26 and 16 years, as classified by TRIM for nine wintering diving duck and seaduck species in Japan. Significant annual changes ($P < 0.05$) are highlighted in bold type. "Moderate increase" means the population indices showed a significant increase of not more than 5% per year. "Stable" means the population indices showed neither a significant increase nor a decrease, and it is certain that trends are < 5% per year. "Moderate decline" and "steep decline" means that the population indices showed a significant decline of not more than 5% and of more than 5% per year respectively. "Uncertain" means that the population indices showed neither a significant increase nor a decrease, and it is not certain that trends are < 5% per year. * = $P < 0.05$, ** = $P < 0.01$.

	Over 46 years (1970–2015)		**Over 36 years (1980–2015)**		**Over 26 years (1990–2015)**		**Over 16 years (2000–2015)**	
Species	**Annual change (%)**	**Long-term trend (TRIM classification)**	**Annual change (%)**	**Long-term trend (TRIM classification)**	**Annual change (%)**	**Long-term trend (TRIM classification)**	**Annual change (%)**	**Long-term trend (TRIM classification)**
Harlequin Duck	**–1.87 (0.005)****	moderate decline	**–4.02 (0.005)****	moderate decline	**–7.22 (0.007)****	steep decline	**–8.71 (0.010)****	steep decline
Long-tailed Duck	**–9.18 (0.030)****	steep decline	**–12.13 (0.032)***	steep decline	**–16.50 (0.051)***	steep decline	**–23.48 (0.041)****	steep decline
Red-breasted Merganser	**–1.36 (0.003)****	moderate decline	**–2.05 (0.004)****	moderate decline	**–3.21 (0.005)****	moderate decline	**–3.94 (0.008)****	moderate decline
Black Scoter	**–2.03 (0.004)****	moderate decline	**–2.08 (0.005)****	moderate decline	**–3.20 (0.008)****	moderate decline	–1.86 (0.015)	stable
Common Goldeneye	–1.14 (0.004)	stable	–0.26 (0.003)	stable	**–0.84 (0.004)***	moderate decline	0.13 (0.007)	stable
Common Pochard	**+2.50 (0.003)****	moderate increase	**+1.86 (0.004)****	moderate increase	**–0.99 (0.004)***	moderate decline	**–3.43 (0.005)****	moderate decline
Greater Scaup	**+2.90 (0.011)****	moderate increase	+0.42 (0.003)	stable	**+1.20 (0.005)***	moderate increase	**–2.61 (0.008)****	moderate decline
Tufted Duck	+0.13 (0.003)	stable	**+0.78 (0.004)***	moderate increase	**+0.88 (0.004)***	moderate increase	–0.26 (0.007)	stable
Velvet Scoter	–4.80 (0.028)	uncertain	–5.28 (0.035)	uncertain	–5.27 (0.055)	uncertain	–9.43 (0.119)	uncertain

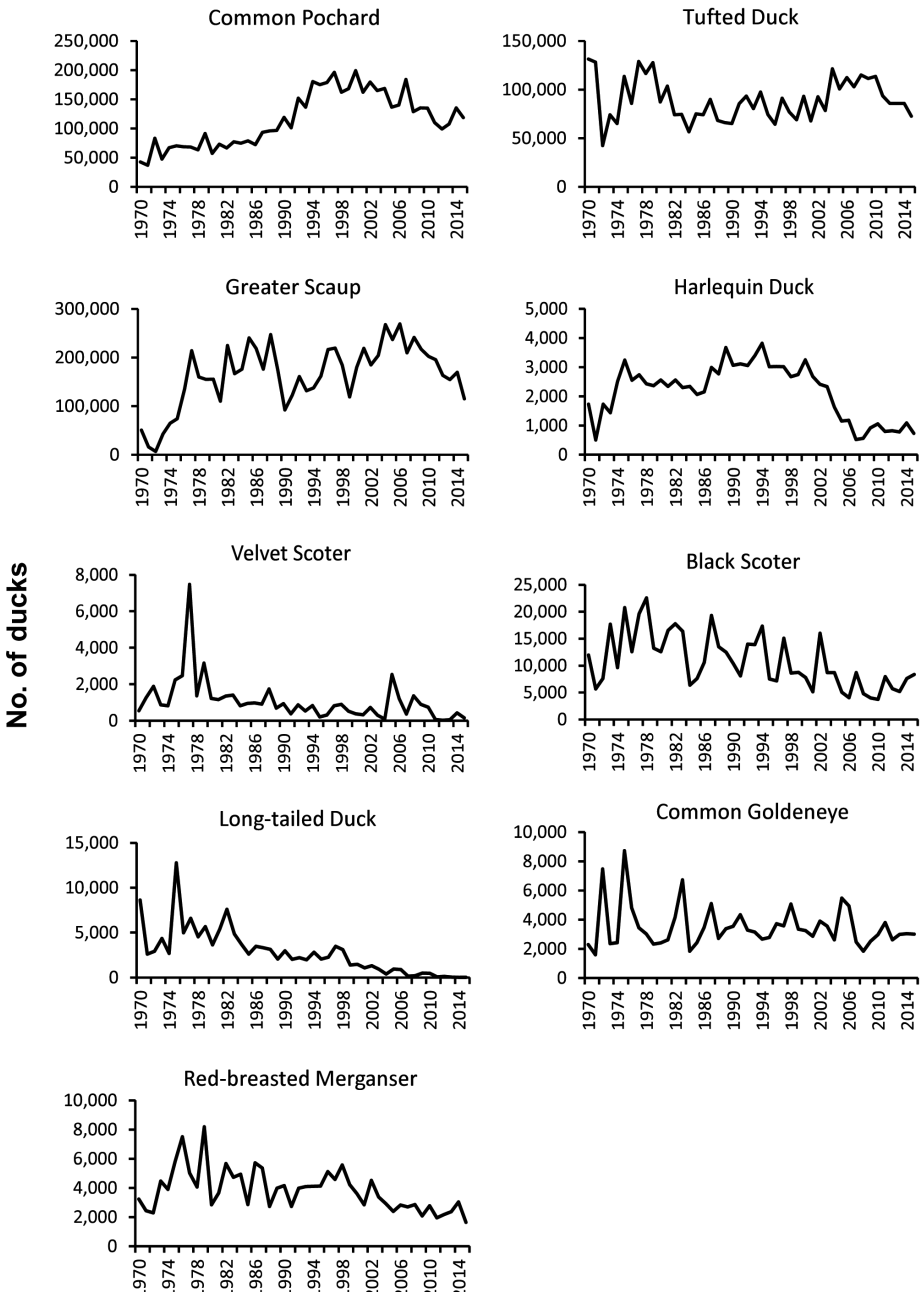

Figure 2. Long-term trends in numbers for nine diving duck and seaduck species wintering in Japan. The annual numbers for each species are abundance indices derived from the TRIM analyses.

most evident in the medium term (*i.e.* over the 26 years from 1990–2015) and more recently their numbers are considered to be "stable" in Japan.

Discussion

The comprehensive monitoring of waterbirds in Japan is to some extent limited by the counts of coastal sites being undertaken from the shore-line, and therefore likely underestimating the true numbers of seaduck species present when the birds move further offshore. Count methods have been consistent throughout the long-term national monitoring programme, however, so results may still be considered indicative of trends in the annual abundance of these species wintering in Japan.

Of the nine duck species considered, five of the diving and seaduck species largely decreased in Japan over the past 16 years, and a further two have declined over the past 26 years. None were found to have increased in numbers over the most recent (16-year) period considered, from 2000–2016. Wintering areas for east Asian populations of four of the species considered – the Harlequin Duck, Black Scoter, Velvet Scoter and Long-tailed Duck – are confined to countries of east Asia, including Japan and the Republic of Korea (Li *et al.* 2009). Further attention therefore should be given to determine the reasons for the trends in abundance of these species in Japan.

Trends in numbers for other populations of these species, for instance those occurring in Europe, have similarly shown no evidence for an increase in recent years (Wetlands International 2016). The Common Goldeneye is generally considered to be "stable" in Europe (Wetlands International 2016), although the Northwest and Central Europe Population is listed as declining in the most recent report on the conservation status of migratory waterbirds submitted to the Meeting of the Parties (MOP) to the African-Eurasian Migratory Waterbirds Agreement (AEWA; Nagy *et al.* 2015). The Long-tailed Duck is classed as "Vulnerable" on the IUCN Red List, following a large decline in numbers of the West Siberia/North European Population in the Baltic Sea, and a draft International Single Species Action Plan has been submitted for adoption by AEWA (Hearn *et al.* 2015). The status of the Harlequin Duck is currently classified as "unknown" in Europe, and populations of the other ducks considered are generally in decline in Europe (Wetlands International 2016). Among the same duck species breeding in North America, annual changes in abundance for Scaup (*A. marila* and *A. affinis*) have exhibited decreases since 1985, and those for Mergansers (*Mergus* sp. and *Lophodytes cucullatus*) and Goldeneye (*B. clangula* and *B. islandica*) showed decreases since 2000 (U.S. Fish and Wildlife Service 2015). It would therefore appear that the changes in annual abundance of diving ducks and seaducks in Japan shows similar decreasing trends with those in other parts of the northern hemisphere.

The trends in annual abundance of the nine common diving and seaduck species wintering in Japan may partly be explained by environmental changes in their wintering areas. Nakamura & Nakamura (1995) divided these nine species into three habitat

types: (i) sheltered bay and lake species: Common Pochard, Tufted Duck and Greater Scaup; (ii) rocky-shore species: Harlequin Duck, Long-tailed Duck and Red-breasted Merganser; and (iii) sandy-shore species: Velvet Scoter, Black Scoter and Common Goldeneye. All three rocky-shore habitat species, as well as Black Scoter, showed long-term declining population trends. Shore-line development, associated pollution and climate change are having potentially adverse influences on seaducks in North America (Zipkin *et al.* 2010). In Japan, development of buildings and other infrastructure along shore-lines increased at a rate of 126.8km/year from 1953 to 1991, which corresponded to a decrease in the extent of sandy and/or gravel shore and rocky shore at a rate of –18.7km/year and –31.5km/year respectively (Kishida 2011). Such habitat loss, together with associated increase in disturbance from human activities would reduce the availability of foraging sites for the rocky- and sandy-shore species. It seems likely that this factor would have contributed to decreases in the three duck species that occur along rocky-shores and Black Scoters which frequent sandy-shore habitat.

Marine pollution (*e.g.* oil, heavy metal and plastic) is also a threat to the seabird habitats (Kazama *et al.* 2010). Although the extent to which these factors are affecting the abundance of seaduck species remains unknown, we cannot exclude the possibility that they also may be influencing their population trends.

Common Goldeneye, Common Pochard, Tufted Duck and Greater Scaup all show broad habitat preferences, ranging from open sea to inland lakes (Higuchi *et al.* 1988); three of these species have declined in Japan since 1990. In Japan, water quality has improved (*i.e.* become more oligotrophic as a result of reductions in nitrogen and phosphate runoff) in most lakes and rivers over the past 10–20 years (Ministry of the Environment 2015), and Haneda (1952) has reported that diving ducks (*e.g.* Common Pochard) tend to occur in mesotrophic and eutrophic lakes that have high productivity. Hence, improvements in water quality may ironically have affected the trends in abundance of these duck species, as a result of reductions in food abundance at inland sites. Declines in Common Pochard in different parts of Europe have also been linked to changes in water chemistry, but with the changes associated with increased intensification of freshwater fish farming in some areas and the abandonment of fish farms in others, depending on the country involved (Fox *et al.* 2016)

Most species of waterbirds wintering in Japan breed in Northern Asia and Far East Russia, so the effects of changing conditions on the breeding grounds should also be considered as a cause of the declines (Higuchi 2012). Although it is unclear what the factors affecting the abundance and declines of species breeding in middle/high latitude regions might be, it has been suggested that the impact of human resource-use across middle latitudes could be greater than that in high latitude regions (*e.g.* WWF International 2014). The Harlequin Duck, which breeds at limited middle latitude regions from the Kuril Islands and the Kamchatka Peninsula to south of Lake Baikal (Kear 2005), may

be particularly affected by the Russian government's development programmes in Far East Russia. A project initiated for the social and economic development of the Kuril Islands is rapidly promoting resource exploitation on these islands (Yamada 2011). Such massive changes in land-use in important areas for waterbirds may contribute to the rapid decreases in the abundance of localised duck species such as the Harlequin Duck.

In order to deliver effective conservation of diving and seaduck species in Japan and East Asia, further studies are required to be undertaken to show the migration routes and define flyways (*e.g.* by using modern telemetry techniques), to map and assess changes in distribution, to identify and protect key sites, and to determine the total population trends at the flyway scale. This requires a combination of coordinated international and national monitoring surveys, together with studies focussing on factors affecting the birds' site use, productivity and survival, in different parts of the flyway.

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