

Research Article

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Population trends, size, and potential threats to Bristle-thighed Curlew *Numenius tahitiensis*: new data from French Polynesia

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Summary

Based on censuses in 2021 and 2022 of Bristle-thighed Curlews *Numenius tahitiensis* on 10 atolls of French Polynesia, the species has declined by c.50% over the last two decades. While the species has recently been down-listed from “Vulnerable” to “Near Threatened”, these new data would qualify it for an “Endangered” Red List status. The non-breeding population on Tuamotu numbers approximately 1,000 curlews and up to 1,500 individuals in all of Eastern Polynesia. On uninhabited islands, the expansion of copra (coconut pulp) exploitation has caused long-term disturbance for curlews, increased predation by pet dogs, and introduced or reinforced non-native rat populations. Climate change, particularly sea-level rise, will add to changes in land use that shrink the suitable habitat for Bristle-thighed Curlews in French Polynesia. As this study shows, obtaining population trends for species breeding in remote areas may best be achieved through surveys at key non-breeding sites.

Introduction

Updating the status and threats of animal population size is of crucial importance for conservation planning. However, for species occurring across large areas and at low densities this can be difficult to achieve. This is the case for many long-distance migrant shorebirds, especially those breeding at remote northern latitudes, and wintering across large geographical regions (Bamford *et al.* 2008). Population status is therefore often assessed by monitoring numbers at major stopover sites (Amano *et al.* 2010), with potential biases ensuing from potential rapid turnover of individuals at stopover sites (Wang *et al.* 2022). Among shorebirds, the Numeniini are of particular conservation concern, with two out of eight curlew species having recently gone extinct (Pearce-Higgins *et al.* 2017). They have some of the largest geographical distributions, and breed at low densities (Pearce-Higgins *et al.* 2017). As a result, estimating the status of their populations is often best achieved through surveys at key non-breeding sites.

This is the case for the Bristle-thighed Curlew *Numenius tahitiensis* breeding in remote tundra habitats in Alaska at low densities (Marks *et al.* 2002), where monitoring breeding numbers is difficult. As a long-distance migrant, Bristle-thighed Curlews winter on islands across a large region of the tropical Pacific, from Hawaii to the Solomon Islands and Eastern Polynesia, down to the Pitcairn Islands (Marks *et al.* 2002). Monitoring of the species has been conducted on a sample of islands (Tibbitts *et al.* 2003 unpublished, 2020). Until recently, Bristle-thighed Curlew had a Red List conservation status of “Vulnerable” (IUCN 2020); however, the species has increased at Oahu, Hawaii Archipelago, following dedicated conservation actions (Tibbitts *et al.* 2020), leading to the downgrading of the population to “Near Threatened” (BirdLife International 2022). Lacking in the Red List assessment was recent information from Polynesia, one of the major curlew wintering areas (Thibault and Cibois 2017). The species is scarce in the Society, Marquesas, and Gambier Islands (Thibault and Cibois 2017), and winters mainly along a north-west–south-east axis in the Line, Tuamotu, and Pitcairn Archipelagos. Censuses dedicated to the species were conducted in the Tuamotu Archipelago in 1988 and 2003 (Gill and Redmond 1992, Tibbitts *et al.* 2003 unpublished).

Within the Tuamotu Archipelago, Gill and Redmond (1992) conducted a survey of Bristle-thighed Curlews present on the atoll of Rangiroa in April 1988. They sighted 144 individuals, distributed between two hotspots, located on the southern and western rims, known as the “pink sands” and “blue lagoon” areas. From these counts, the authors further estimated an overall abundance of 250–350 curlews on Rangiroa. The surveyed areas were precisely mapped (Gill and Redmond 1992), so that repeating a similar survey would be feasible. Tibbitts *et al.* (2003 unpublished) surveyed several atolls in the Tuamotu Archipelago in March 2003, censusing curlews (among other species) using a standardised method. They counted a total of 202 curlews on Haraiki, Reitoru, Tekokota, Manuhangi, Paraoa, and Ahunui. In October–November 2021 and April 2022, I organised two expeditions in the Tuamotu Archipelago, and surveyed the seven

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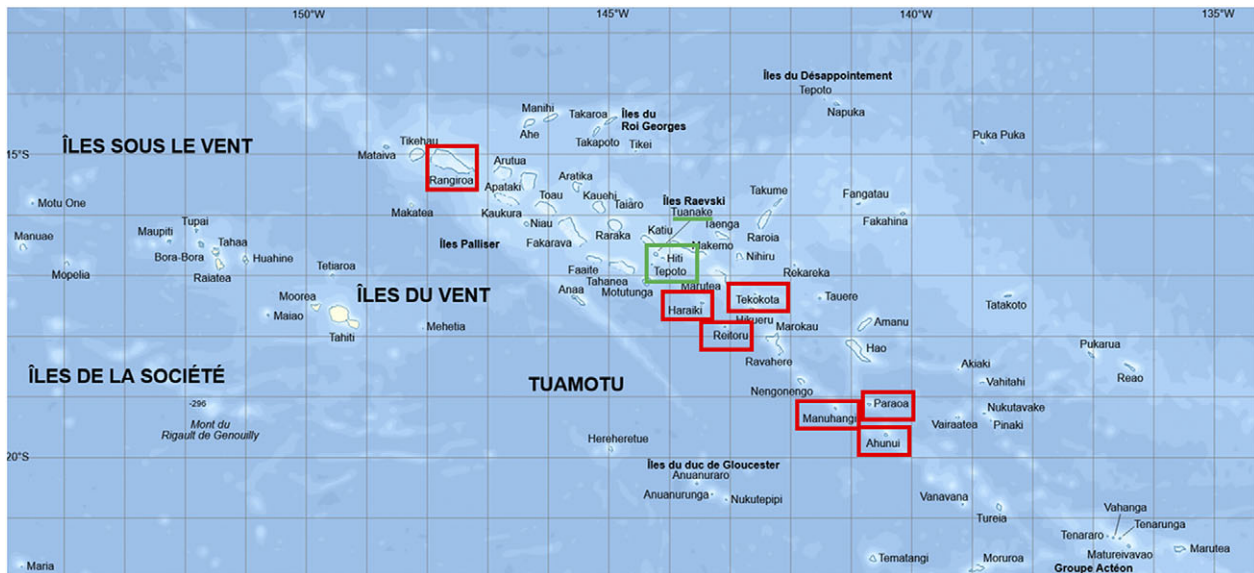


Figure 1. Location of the surveyed atolls in the Tuamotu Archipelago, French Polynesia. An atoll is a ring-shaped coral reef, island, or series of islets (called motus), surrounding a body of water called a lagoon. Red squares identify atolls where curlews have been counted during two previous periods, the green square indicates three uninhabited atolls surveyed in 2022 only. Only Rangiroa is permanently inhabited, all other surveyed atolls are uninhabited.

atolls cited above, plus three additional uninhabited atolls (Tepoto, Tuanake, and Hiti) (see Figure 1), to count Bristle-thighed Curlews. I aimed to compare the most recent census with the numbers detected previously in order to estimate trends in curlew numbers wintering in the Tuamotu Archipelago.

The global population of the Bristle-thighed Curlew is estimated to number 10,000 individuals, including sub-adults, with fewer than 7,000 breeding adults in Alaska (Marks *et al.* 2002, Andres *et al.* 2012), but these estimates are over two decades old. Numbers at the two main wintering areas were estimated at 1,100 individuals for the Hawaiian Archipelago (Marks *et al.* 2002), and 1,100–2,500 individuals for Eastern Polynesia (Thibault and Cibois 2017).

The goal of this paper was to update the current population estimate for Bristle-thighed Curlew in French Polynesia with data collected in 2021–2022, compare recent numbers with historic survey estimates, and to give an overview of threats curlews face in Polynesia.

Methods

At Rangiroa, the survey concerned the former southern-rim hot-spot (pink sands) on 25–26 October 2021, the different motus (islets) of the western rim (blue lagoon) from 30 October to 02 November 2021, and the rat-free motus in between these on 18 April 2022. All parts of the atoll where curlews can occur were surveyed. The rest of the atoll is highly frequented by humans, with rat-infested degraded habitats unlikely to be favoured by curlews.

I also organised a complete survey of the nine smaller atolls (Haraiki, Reitoru, Tekokota, Manuhangi, Paraoa, Ahunui – already surveyed in 2003 – and also Paraoa, Ahunui, and Manuhangi). During the 2003 March expedition of Tibbitts *et al.* (2003 unpublished), all detected curlews had been observed in open and shrub habitats, so the 2022 survey focused on these habitats, using a similar survey protocol. In 2003, the protocol involved three to nine observers lined up perpendicularly across an atoll spaced at

about 50–200 m intervals from the ocean reef flats to the lagoon shore. Observers then proceeded to walk slowly along the length of the atoll within a designated habitat type (i.e. lagoon edge, inner vegetation edge of the motu, forest interior, ocean beach, ocean reef flats, and oa, which is a spillway where water passes between ocean and lagoon). Around 91% of the detected curlews were located along shores in unvegetated habitats, and 9% in open shrub areas in the interiors of motus. In April 2022, we carried out a similar census on the nine atolls. We surveyed each atoll with a team of five to six observers by walking systematically along the reef and lagoon shores, mapping any encountered curlew, and noting its behaviour and movements, to avoid double counting. Observers lined up from the ocean beach to the shrub areas bordering the shore to cover all possible open habitats. We visited Tepoto on 05 April, Tuanake 06 April, Hiti 07 April, Haraiki 08 April, Reitoru 09 April, Tekokota 10 April, Manuhangi 12 April, Paraoa 13 April, and Ahunui 14 April.

I used a generalised linear model to compare numbers between the two census periods, considering a Poisson distribution for count data and a site effect (atoll) in the model. To estimate the maximum number of curlews wintering in the Tuamotu Archipelago, Thibault and Cibois (2017) multiplied the number of uninhabited atolls (30) by the average estimate of curlew number per atoll. I used the same calculation method to propose an update of the population size wintering in the Tuamotu Archipelago.

Results

Population changes

At Rangiroa, we counted 85 curlews on the western rim in October 2021, mostly present on one large ocean reef terrace. One motu had the largest number of individuals (70) observed on 30 October. On the other motus we surveyed at the blue lagoon, we detected a further five (Taeoa), five (To ai ai), and five (Ihiti and Tereia) curlews, while the small aligned motus of Taumaha, Opuia, and Iore were not occupied by the species (Figure 2). We observed

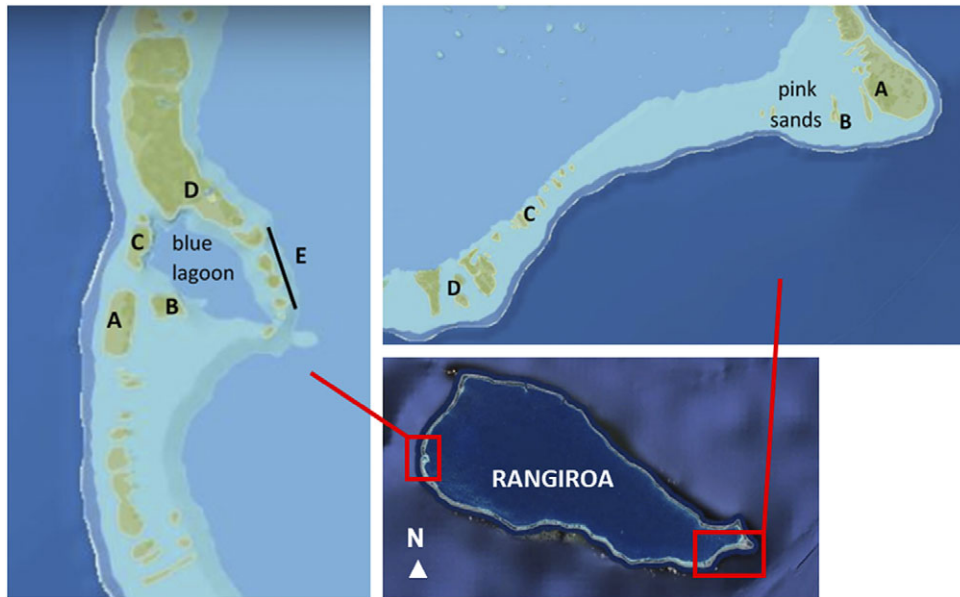


Figure 2. Map indicating the locations of the motus of the southern and western rims of Rangiroa atoll, Tuamotu Archipelago. For the southern rim, at the pink sands, letters locate the following motus: A Vahituri, B Huehue, C Atiati rahi, D Ovete, Rama, and Teu. For the western rim, at the blue lagoon: A Natonato; B Taeo; C To ai ai; D Ihiti, Tereia; E Taumaha, Opu, and lore.

23 curlews on the southern rim hotspot, the largest group being three birds. These birds were distributed across four sites, Vahituri (eight individuals), Huehue (two individuals), Atiati rahi (five individuals), and Ovete-Rama-Teu (eight individuals) (Figure 2). In April 2022, we counted 11 curlews on the motus between the southern and western rim (from Ofe Ofe to Omai and Taereere). The summed number of curlews on Rangiroa was 119 individuals. On the six uninhabited atolls already surveyed in 2003, we counted a total of 113 curlews. On six supplementary uninhabited atolls, we counted one curlew on Tepoto, eight on Tuanake, and three on Hiti. The average \pm SD number of curlews on uninhabited atolls was 14 ± 11 (25 ± 35 if considering Rangiroa too). A decrease in number was observed for six of the seven islands, while numbers seemed stable on Manuhangi. Note also that we visited Reitoru and Tekokota in January 2021, when we conducted an exhaustive count of curlews present on these atolls (values reported in Table 1). Overall, we reported a decline of 49–58% in numbers, with a total of 232 detected curlews, compared with 452–552 in 1988–2003. The decrease could be even larger at Paraoa and Ahunui, where Tibbitts *et al.* (2003 unpublished) spent only two hours partially prospecting each of these atolls, while we surveyed them completely. The difference in counts between the two periods was statistically significant ($z = 9.6$, $P < 0.001$).

Population size

During our surveys in 2021 and 2022, we detected on average 14 curlews per uninhabited atoll, with high uncertainty (95% confidence interval [CI] 4–25). Multiplying the number of uninhabited atolls (30) by an average estimate of 14 curlews per atoll (like Thibault and Cibois 2017), we would consider that the Tuamotu population is now 700 individuals (95% CI 200–1,250). There is evidence that inhabited atolls do host some curlews, sometimes in good numbers, such as Rangiroa where the few rat-free motus host up to 120 individuals. There are 77 islands and atolls in the Tuamotu Archipelago (both habited and uninhabited), and if

applying the same average abundance to inhabited atolls as for uninhabited atolls, this would produce an overall estimate of 1,060 curlews wintering there. We therefore propose an estimate of 1,000 individuals (95% CI 308–1,925) present during the non-breeding season across the Tuamotu Archipelago.

Discussion

Population trends

The recent censuses of Bristle-thighed Curlews in the Tuamotu Archipelago strongly suggest that the population has declined since the late 1990s. On Rangiroa, numbers have dropped by one half to two-thirds since the late 1980s and by nearly a half on other atolls since the early 2000s. The value of -44% obtained by comparing detected numbers is probably an underestimate, as two atolls, Paraoa and Ahunui (see Table 1), had been only partly surveyed in 2003 (Tibbitts *et al.* 2003 unpublished), but completely in 2022 (this report), so that the respective decreases of -54% and -26% are likely to be over-optimistic. Overall, the decline of the species in the Tuamotu Archipelago could reach a magnitude of 50%. According to the IUCN rules for determining the Red List status of a species (IUCN 2022), the Bristle-thighed Curlew would qualify for an “Endangered” threat category, based on criteria A.2b: “population reduction observed in the past, from an index of abundance appropriate to the taxon, where the causes of reduction may not have ceased or may not be understood or may not be reversible”. Recently, the Bristle-thighed Curlew has been downgraded from a “Vulnerable” to a “Near Threatened” threat category, according to the following arguments (BirdLife International 2022): (1) on the non-breeding grounds in Oceania, the species is thought to be stable in French Polynesia, or even increasing on Oahu (Hawaii) (Tibbitts *et al.* 2020); (2) growing evidence that population declines have stopped or at least slowed down considerably; (3) in the absence of data covering the entire range, it is precautionarily suspected that the species has been undergoing a slow decline over

Table 1. Numbers of Bristle-thighed Curlews detected at seven atolls in the Tuamotu Archipelago during the 2021–2022 expeditions and previously published fieldwork, with the corresponding rate of change in numbers, and also coordinates, permanent presence of humans (yes/no), and presence of Pacific rats.

Atoll	Latitude	Longitude	Area (km ²)	Humans	Rats	1988	2003	2021–2022	Change
Rangiroa	15°07' S	147°39' W	79	yes	yes/no	250–350		119	–52/66%
Haraiki	17°28' S	143°28' W	3.5	no	yes		31	21	–32%
Reitoru	17°51' S	143°04' W	1.4	no	yes		42	12–10	–76%
Tekokota	17°19' S	142°37' W	0.9	no	no		13	5–4	–69%
Ahunui	19°37' S	140°23' W	5.7	no	yes		28	28	0%
Paraoa	19°08' S	140°40' W	4	no	yes		54*	25	–54%
Manuhangi	19°12' S	141°15' W	1	no	yes		34*	25	–26%

*Atolls that have only been partly counted (in 2003).

the past three generations (23.1 years), which is unlikely to exceed a rate of 5–10%. The results presented here in fact present evidence to the contrary for French Polynesia – that at least in the Tuamotu Archipelago, Bristle-thighed Curlews have declined in recent years, and are not in fact stable. Indeed, Tuamotu atolls have not benefitted from extended conservation action dedicated to the species as has occurred on Oahu (Tibbitts *et al.* 2020).

Having only two time periods to compare numbers is not ideal, but curlews are long-lived species known to display winter site fidelity (Sanders 2017, Coates 2018), so no large year-to-year variations in numbers are expected, and so these results present a useful comparison of similar data obtained at two different time periods.

Population size

Thibault and Cibois (2017) proposed an estimation of a maximum number of curlews wintering in the Tuamotu Archipelago by multiplying the number of uninhabited atolls (30) by an average estimate of 50 curlews per atoll, hence 1,500 individuals. The previous estimate of the Tuamotu population size they proposed was therefore 450–1,500 individuals, with a range of 1,100–2,250 for Eastern Polynesia. It seems that these authors did not consider the estimated 250–350 individuals on Rangiroa from Gill and Redmond (1992), so their figures should be increased to 700–1,850 for Tuamotu, and 1,350–2,600 for Eastern Polynesia. From our updated counts, I tentatively propose a similar figure for the Tuamotu population, with a 95% CI of 308–1,925, and an average size probably close to 1,000 individuals, while the population in the whole of Eastern Polynesia could number approximately 1,500 individuals.

As Bristle-thighed Curlews occur at low densities within their breeding and non-breeding ranges, estimating global population size is not straightforward. The estimates provided here for the Tuamotu Archipelago and Polynesia illustrate this complexity: they stand within the range proposed previously, despite an attested decrease in numbers on a sample of monitored islands. If the global population numbered 10,000 individuals in the early 2000s, and if Polynesian numbers have halved, the global numbers have certainly dropped.

Potential threat overview

Like other Numeniini species (Pearce-Higgins *et al.* 2017), Bristle-thighed Curlews face a host of threats on the Tuamotu Archipelago. Curlews are scarce on inhabited motus, where disturbance can

occur either by humans, dogs, or cats. Tourism activities can disturb curlews on remote motus, for example at the blue lagoon of Rangiroa, where daily excursions are organised to some islets. However, most birds there stay on the reef or in coconut plantations and the species benefits from strict protection in French Polynesia – even photographing the species is forbidden. However, disturbance can have an impact locally, and curlews have a larger flight distance on atolls where human occupation is not permanent but regular (e.g. for copra exploitation, see below), while they are particularly tame on atolls with no easy access (e.g. southern atolls with no pass to access the lagoon by boat; pers. obs.), that humans do not visit frequently, and that hold no dwellings. Though the species is fully protected in French Polynesia, there is also evidence of recent hunting by humans in the Tuamotu Archipelago as a traditional food source at sites where the species is abundant. I gathered testimonials to this effect at Rangiroa, where the collection of a few curlews occurred at the blue lagoon at least until 2017; however, this threat is probably not a major one, contrary to what occurred previously (Gill and Redmond 1992).

The Bristle-thighed Curlew is known to be highly vulnerable to predation by introduced mammal predators during its wing moult, as many birds become flightless (Marks *et al.* 1990, Marks 1993). I had no evidence of flightless moulting birds in October–November in the Tuamotu Archipelago, similar to reports from the Pitcairns (Thibault and Cibois 2017), but refuelled individuals just before the spring migration are very reluctant to fly, and are easy prey for nocturnal predators such as wandering dogs.

Rats are perhaps the largest threat to the Bristle-thighed Curlew in the Tuamotu Archipelago. Two rat species have been introduced into Polynesia: the Pacific Rat *Rattus exulans* and the Ship Rat *R. rattus*. The former is smaller, more widely distributed, and present on many atolls where curlews are present (on eight of the nine uninhabited atolls I visited – all except Tekokota which is rat-free). The second species has not been observed on these nine atolls, and is not present on motus of Rangiroa holding curlews. Rats impact native populations of reptiles and invertebrates (Harper and Bunbury 2015), which also decreases the overall terrestrial food availability for curlews (lizards, arthropods, crabs; pers. obs.). For example, the southern rim of Rangiroa is now rat-infested (I saw several Pacific Rats while prospecting for curlews in October 2021), and curlew numbers have shrunk there since the late 1980s, while on the western rim, the few motus which still hold large numbers of curlews are rat free (Natonato and Taea). Rat expansion in both range and numbers is still occurring, especially due to humans coming to uninhabited atolls to exploit copra, but also to unusual flooding events in lagoons which can displace rats to uncolonised motus.

Copra exploitation is also a threat to curlews. The Polynesian government provides subsidies to maintain this traditional activity on remote uninhabited atolls. It consists of harvesting mature coconuts, extracting and drying the coconut albumen, and exporting it to inhabited islands. Copra exploiters transport burlap bags on their boats, and are responsible for recurrent rat translocations to remote islands, either contributing to novel introductions or increasing existing populations. During our visits to the Tuamotu Archipelago, we encountered several copra exploiters who resided on remote islands with pets, either dogs for their own company, or cats to limit rat numbers at their campsite. Finally, copra exploiters often systematically set fire to the understorey after exploiting a plantation, with the aim to clean the undergrowth of the plantations and fertilise the soil; however, fires destroy most plants and invertebrates, and even coconut trees. As far as biodiversity conservation is concerned, I highly recommend that copra activity is strictly controlled on remote islands or those islets with curlews on inhabited atolls, that dogs and cats are banned, that burlap bags and boats are checked to ensure they do not shelter rats, and that the understorey is not burned after exploitation.

Climate change represents a current and a future threat to the species, related to sea-level rise and migration mismatch. Sea-level rise will reduce the available foraging habitat (Bellard *et al.* 2013, Courchamp *et al.* 2014) at reefs and coastal marshes but also on terrestrial motus that can be flooded by waves. As an example, the motu holding most curlews at the blue lagoon of Rangiroa, is a maximum of 6 m above sea level, and >90% of its area is below 5 m (see <https://fr-fr.topographic-map.com/places/65m/Polynésie-française/>). The increasing frequency and intensity of tropical storms in the Pacific due to climate change (Wu *et al.* 2018) will also provoke more frequent and intense submersions, and these temporary submersions can also favour rat dispersal. Finally, as Bristle-thighed Curlews are long-distance migrants which move latitudinally across the Pacific Ocean (Jetz *et al.* 2021), potential changes in wind patterns and climatic conditions during their migration may also affect the success of their migration attempts. For example, recent climatic changes during migration can constrain their ability to return to the northern breeding grounds (Senner 2012). Further research is needed to evaluate this possibility.

Governments, inter-governmental organisations, and NGOs, including BirdLife International partners, should address these issues across the whole range of the Bristle-thighed Curlew, especially in the context of increasing its Red List status. Marks and Redmond (1994) called for action to fill the gaps in knowledge on Bristle-thighed Curlews in their wintering range. They recommended that future studies should: identify concentrations of wintering curlews, focusing on the Tuamotu Archipelago; determine whether migratory stopover sites exist in the central Pacific between Hawaii and the southern extremity of the wintering grounds; establish a monitoring programme to assess population trends in several parts of the winter range. The surveys conducted in 2022 have contributed to providing estimates of trends in this region often considered to comprise the major wintering grounds of the species. Ongoing ringing and tagging of Bristle-thighed Curlews will certainly provide useful information on the migratory strategy of the species.

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