







**NOTE**

# Humpback whales (*Megaptera novaeangliae*) return to Cumberland Bay, South Georgia, one century after the peak of whaling

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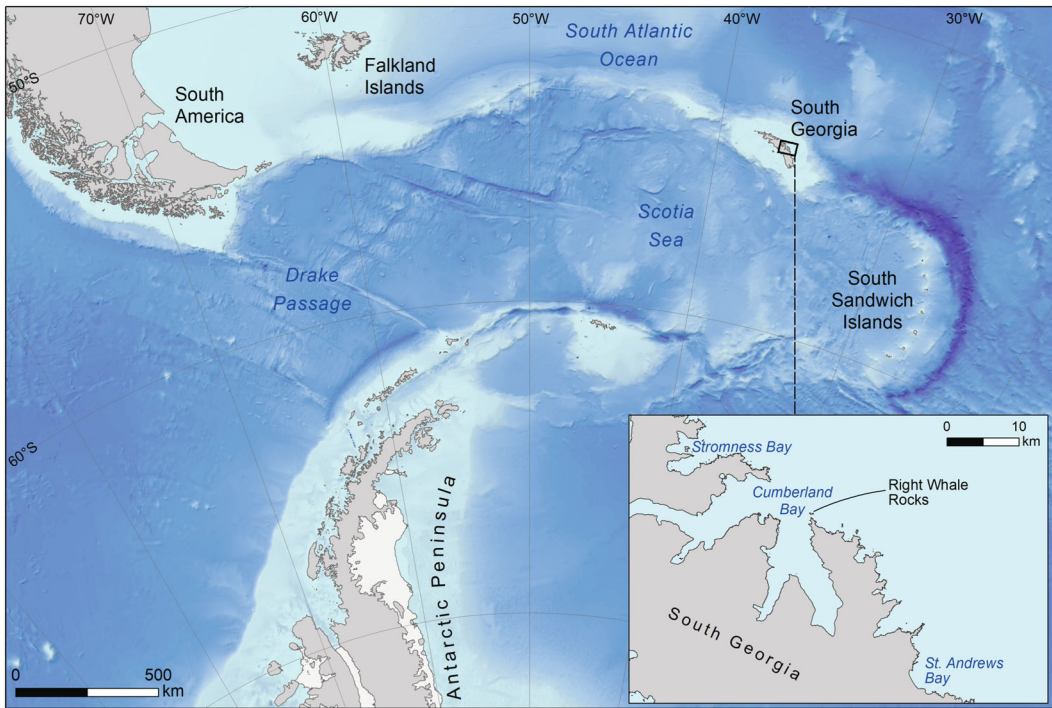
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South Georgia island in the sub-Antarctic waters of the South Atlantic is where modern whaling began in Southern Ocean waters in the early twentieth century (Tønnessen & Johnsen, 1982). By 1900, historical and modern whaling had drastically reduced or effectively wiped out some populations of baleen whales across much of the North Atlantic and North Pacific (Clapham & Baker, 2002) and whalers were keen to exploit new seas. Norwegian whaler Captain C. A. Larsen first visited South Georgia island in 1892 while prospecting for new whaling sites. Larsen identified that the abundance of whales made South Georgia a promising site, particularly for whaling of blue (*Balaenoptera musculus*) and fin (*B. physalus*) whales (Hart, 2021), and identified the more protected north side of the island, and in particular the wide natural harbor of Cumberland Bay, as the best site for operations (Figure 1). After securing expedition funding, including one whale catcher vessel (the 33.5 m *Fortuna*), Larsen and his team arrived in South Georgia on November 16, 1904, to set up the Grytviken whaling station in Cumberland Bay.

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**FIGURE 1** Map of South Georgia in the southwest Atlantic, with inset showing 2019 survey area around Cumberland Bay.

Wasting no time, Larsen's men began whaling by December 2, when they killed their first humpback whale (*Megaptera novaeangliae*). In their first season of whaling, they found sufficient whales in Cumberland Bay that the *Fortuna* did not need to venture outside the protected waters. In particular, they found large numbers of humpback whales close to the coast; by April 1905, 91 whales had been taken in Cumberland Bay, 67 of which were humpbacks (Hart, 2021). In 1905, the catcher fleet doubled in size, and by 1907 two other whaling stations were setting up in nearby Stromness Bay (Hinton, 1925). South Georgia island rapidly became an epicenter of Southern Hemisphere whaling, with over 176,000 whales killed in 62 years of operation (Allison, 2020).

Humpback whales feeding in the waters surrounding South Georgia have been linked with wintering grounds on Abrolhos Bank off Bahia, Brazil (Stevick et al., 2006; Zerbini et al., 2006, 2011), where in 1912 one British-owned and two Norwegian-owned companies were capturing humpback whales (de Morais et al., 2017; Edmundson & Hart, 2014; Hart & Edmundson, 2017). In the early 20th century, South Georgia was clearly an important summer feeding ground for this population, with 28,863 humpbacks killed during local whaling operations, over 24,000 of those between 1905 and 1916. It is worth noting that the historic catches made at South Georgia alone (1904–1966, 26,863 whales) were higher in magnitude than the most recent abundance estimate for this recovering population (estimated at 20,389 in 2012; Bortolotto et al., 2017), emphasizing just how numerous this species was on the South Georgia whaling ground. In 2019, this southwest Atlantic humpback population was estimated to be ~93% recovered (Zerbini et al., 2019).

With southwestern South Atlantic humpback whales now close to recovery from exploitation (Zerbini et al., 2019), one pressing question is whether they are now using South Georgia coastal waters to the same extent as they did a century ago. The South Georgia whaling industry ended in 1966, when a lack of whales and a decline in the commercial market value of whale oil forced the stations to close. Even though the numbers of vessels visiting South Georgia were limited prior to the 2000s, it is notable that humpbacks were rarely seen there in the four decades since local whaling ended (Moore et al., 1999; Reid et al., 2000). For instance, a survey of the northern shelf

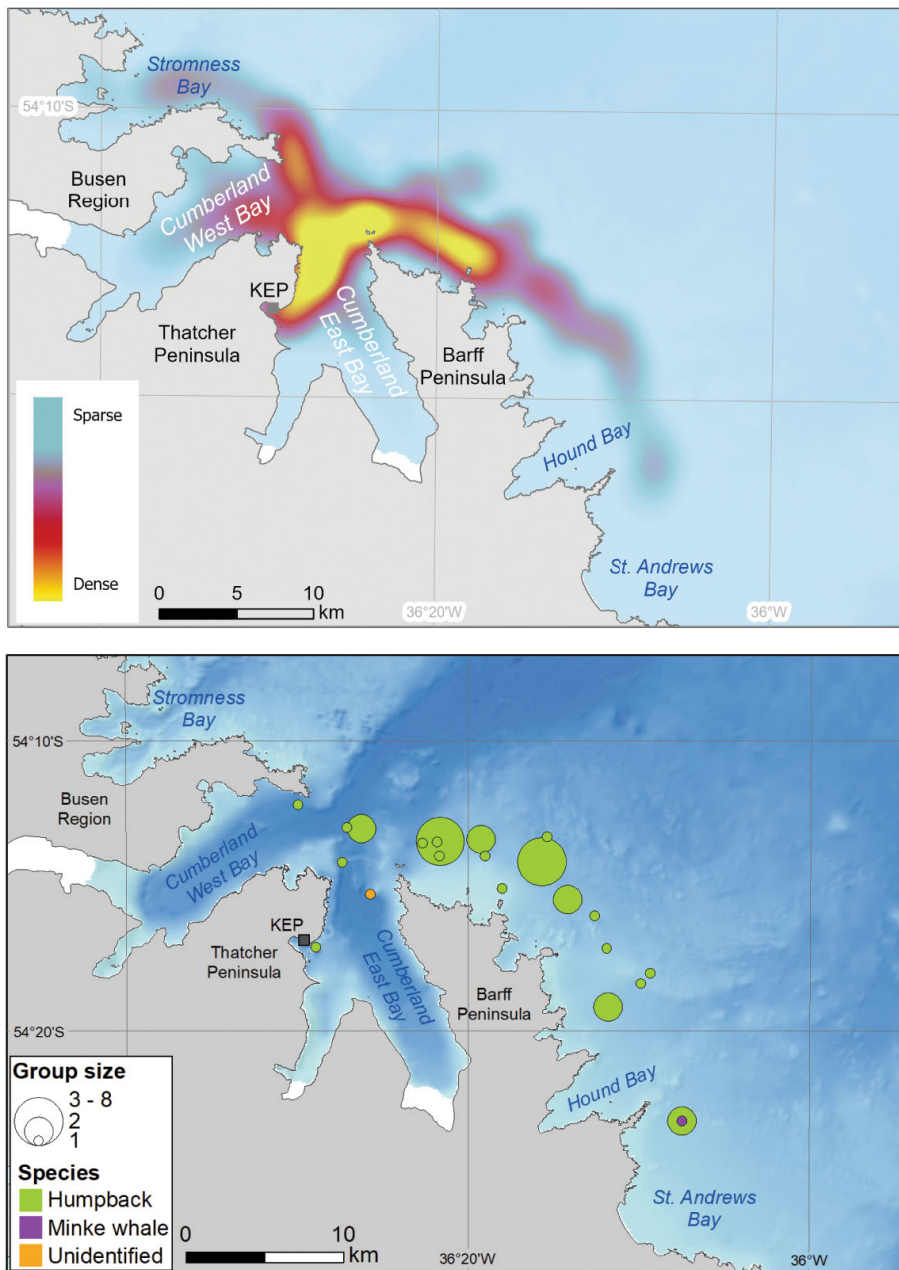
of South Georgia in 1997 reported only four humpback whales (Moore et al., 1999). A subsequent survey of South Georgia and the Scotia Arc in 2000, while hampered by fog and high seas, observed only 29 humpback whales in the Scotia Arc, of which none were sighted near the South Georgia coast (Hedley et al., 2001; Reilly et al., 2004); an estimated Scotia Arc abundance of 2,493 (coefficient of variance,  $CV = 0.55$ ) humpback whales (Reilly et al., 2004). Nearly two decades later, in the austral summer of 2018/2019, a ship-based survey conducted whale sighting transects predominantly to the northwest of the island and estimated that 12,103 humpbacks ( $CV = 0.27$ ) were using South Georgia waters (Baines et al., 2021). When combined with coordinated ship-based surveys across the Scotia Arc, abundance of humpback whales ( $CV = 0.26$ ) was estimated at 24,543 across the Scotia Arc in 2018/2019 (Baines et al., 2021). This represents an order of magnitude increase in humpback abundance in the Scotia Arc within the time frame of one humpback generation ( $\sim 20$  years; Taylor et al., 2007).

As recently as 2008, South Georgia humpback whales were held up as an example of a subpopulation that had been extirpated by whaling, possibly due to loss of cultural memory of the habitat and excessive exploitation of whales in adjacent regions, reducing the capacity of either focal or neighboring populations to recolonize this feeding ground (Clapham et al., 2008). Indeed, long-term satellite tracking of humpback whales from their Brazilian wintering ground has primarily shown migrations towards the South Sandwich Islands, an island chain 300 nmi east of South Georgia (Zerbini et al., 2006, 2011). This migratory pattern appears to have been consistent over 15 years of surveys and is also supported by the spatial pattern of illegal Soviet catches in the 1960s (Horton et al., 2020). However, the 2018/2019 whale survey estimated that the South Sandwich Islands now have a similar level of humpback abundance to South Georgia, although with broad confidence intervals (South Sandwich Islands abundance = 11,656,  $CV = 0.36$ ; Baines et al., 2021). Changes in oceanographic conditions and the distribution of humpback whales' primary food, Antarctic krill (*Euphausia superba*), over the intervening century may have also played a role in changing the habitat-use preferences of humpbacks in the South Atlantic. There is evidence that Antarctic krill distribution has contracted southwards in the Scotia Arc over the last 90 years, with densities declining sharply at the northern limit of their range around South Georgia (Atkinson et al., 2019).

A recent review of 28 years of opportunistic mariner reports to the South Georgia museum suggested that humpback whale numbers are increasing in South Georgia waters over time (Jackson et al., 2020). These opportunistic reports were mostly confined to nearshore waters around the northern coast. They showed humpback whales sighted at a rate of 5–40 whales annually between 1991 and 2010 (Richardson et al., 2012), with median reported group sizes increasing from 1 to 4 animals (between 1992 and 2010) to 5+ animals after 2011, suggesting an increasing presence (Jackson et al., 2020).

Cumberland Bay was the first place at South Georgia where whalers hunted. Around 115 years after whaling first began there, we conducted a new whale sighting survey in Cumberland Bay and nearshore waters in January and February 2019, to assess the numbers of whales using this area of South Georgia. The bay has a mouth just under 4 nmi wide, and two enclosed arms, the larger one containing Grytviken whaling station (see scale in Figure 1). Between January 5 and February 24, 2019, 15 whale sighting surveys were conducted either in Cumberland Bay alone, or Cumberland Bay and adjoining waters (within 5 nmi of the coast) between Stromness Harbour ( $36^{\circ}37'34''W$ ) and St. Andrews Bay ( $36^{\circ}03'07''W$ ; Figure 1). Surveys were conducted only in Beaufort Sea States 1–4 and swell  $<2$  m. Surveys were carried out by four experienced personnel on a harbor launch (10.5 m Marine Ribworker, platform height above sea level 1–2 m) who scanned the ocean by eye and with marine binoculars (Fujinon  $7 \times 50$ ). Two personnel also surveyed at the same time from a RHIB (5.5 m Humber Destroyer) that traveled parallel to or in the vicinity of the harbor launch ( $<1$  nmi range) at all times. Due to safety considerations, both vessels traveled via fixed waypoints both in Cumberland Bay and along the coast (Figure 2).

Activities during survey on the harbor launch were categorized into three modes; traveling ( $>10$  kn speed), sea-transect (10 kn, two personnel surveying for whales off the port and starboard side of the vessel, respectively), and research mode (conducting photo-ID, biopsy, unmanned aerial vehicle, or satellite tagging operations). Survey tracks were collected using a handheld Garmin GPS unit on the harbor launch. Wind direction, sea state, swell height, and visibility were recorded by hand. Data were updated every 15 min while searching for whales, or when environmental conditions or effort status changed. Environmental conditions were also recorded with every sighting. When



**FIGURE 2** A heat map of survey effort at South Georgia during the field season in January–February 2019 plotted in ArcGIS, with areas of highest frequency survey effort shown in yellow (top). King Edward Point station (KEP) is shown with a square; Grytviken whaling station is 800 m west of this location. Distribution of cetacean sightings (bottom).

whales were sighted, the team went into “research mode” and either collected photo-ID of the whale(s) or transferred personnel to the RHIB to conduct biopsy sampling or satellite tagging activities.

Over the 2019 survey period, Cumberland Bay alone was surveyed six times. Cumberland Bay plus adjoining waters were surveyed nine times, a total of 25:12 hr:min of search effort over all surveys. Nine expeditions were carried out in January (13:39 hr:min effort, with whales sighted on six surveys) and six in February (11:33 hr:min effort, with whales sighted on three surveys). A total of 43 whales (41 humpback whales) were observed during 26 sighting

events, nine of which were within Cumberland Bay (including one off-effort during a test run); a further 10 humpback whales were sighted at the entrance to the Bay (Right Whale Rocks), making a total of 19 humpback whale sightings within or at the entrance to Cumberland Bay (Table 1). Mother-calf pairs were encountered during three sightings on February 2, 4, and 22. Most whales were singletons and were observed to be either feeding or traveling. We identified “groups” of whales as those that were seen in close association with one another. While the median group size was one both inside and outside the bay, larger groups of whales (largest estimated group size = 8) were more regularly sighted outside or at the entrance of the bay (Figure 2), suggesting more limited feeding opportunities farther inside. Sightings and effort data from this survey are available from the British Antarctic Survey Polar Data Centre (<https://doi.org/10.5285/33204189-2ECB-4F6B-B3E2-E1B7BC4339DB>).

A comparison of 2019 sightings with whaler catches made in 1905 (Table 2) shows two similarities; firstly, the same number of humpback whales were encountered by both expeditions in Cumberland Bay in January, and secondly, humpback whales were the predominant species sighted/hunted. In contrast, fewer sightings of humpbacks were made in Cumberland Bay in February 2019; poor weather meant that only six surveys could be conducted, with only two whales sighted in Cumberland Bay at this time (both in the Right Whale Rocks region). In 1904, other baleen whale species, including blue and fin whales, were caught in Cumberland Bay. Neither species was observed during the 2019 coastal surveys, nor regularly reported in coastal waters by mariners (Calderan et al., 2020; Richardson et al., 2012), although one photographically confirmed sighting of a blue whale in east Cumberland Bay was made by a British Antarctic Survey scientist on October 30, 2019, and blue whales were frequently seen offshore during a subsequent survey in 2020 (Calderan et al., 2020).

The 2019 coastal surveys demonstrated that humpback whales are now regularly seen close to the coast of South Georgia, consistent with more broad-scale observations made during a ship-based survey in the same year (Baines et al., 2021) and sighting reports over the previous decade by tourists and mariners (Jackson et al., 2020). Quantitative comparisons with the whaling period are not possible, as the amount of time the whalers spent searching for whales (effort) is not known and the survey platforms differed, but the use of a single catcher vessel working in the same location (Cumberland Bay) in 1905 helps to provide a qualitative comparison with current

**TABLE 1** Number of whale sightings by species during coastal surveys of South Georgia in January and February 2019.

Scientific name	Common name	Total individuals	Total sightings	Median group size	Group size	Individuals photo-identified	Biopsy sample
<i>Megaptera novaeangliae</i>	Humpback whale	41 (19) <sup>a</sup>	25 (11)	1	1–8	26	12
<i>Balaenotera bonaerensis</i>	Minke whale	1	1	1	1	0	0
<i>Balaenoptera</i> spp.	Unidentified baleen whale	1 (1)	1 (1)	1	1	0	0
Totals		43 (20)	26 (12)	3	1–8	26	12

<sup>a</sup>Number of whales sighted in the vicinity of Cumberland Bay shown in parentheses.

**TABLE 2** Comparison of Cumberland Bay catches in 1905 by whaler *Fortuna* and 2019 sightings of humpback whales by month.

Month	1905 catches			2019 sightings	
	Humpback	Blue	Fin	Humpback	Unidentified
January	17	3	5	17	1
February	10	4	5	2	0
Totals	27	7	10	19	1

sightings. Cumberland Bay is easy to survey as it is relatively small, so if whales are present in the bay, the chances of sighting them are expected to be close to 100% for both whale surveyors and the catcher vessel under fair sighting conditions. In 1904/1905, whalers were restricted by the processing capacity of their station, so may have caught less than the total number of whales than were present in the bay during this season (I. H., personal observation). However, whaler effort is still likely to have been significantly higher than whale survey effort, since whalers operated in a broader range of weather conditions and could operate throughout daylight hours, while whale surveys were constrained to 6-hr periods due to safety considerations. In Cumberland Bay, 2019 surveys sighted 70% of the number of humpback whales caught by the whalers over January and February in 1905. Considering the likely substantial differences in effort, this suggests a strong nearshore presence of humpback whales in Cumberland Bay and the local area, potentially at similar densities to those encountered at the start of South Georgia whaling in 1904.

Our sighting patterns are consistent with the broader pattern of humpback whale recovery in numerical terms in the southwestern South Atlantic. The main summer feeding area for this population is the Scotia Arc, encompassing South Georgia (to the north), the South Sandwich Islands (to the east), and offshore areas of the central Scotia Arc (including the South Orkney Islands to the south) (Zerbini et al., 2019). In summer 2018/2019, multiple vessels were used to conduct ship-based surveys for cetaceans across this region, yielding an estimate of humpback whale abundance which represents the span of their Scotia Arc feeding ground (24,543 whales,  $CV = 0.26$ ; Baines et al., 2021). This value is very close to the level of abundance predicted for this population prior to whaling (24,925, probability intervals 22,369–27,007; Zerbini et al., 2019), supporting the hypothesis that humpback whales are now over 93% recovered from whaling in the southwestern South Atlantic (Zerbini et al., 2019).

Antarctic blue and fin whaling at South Georgia began in earnest after the humpback whales were mostly wiped out, and the catcher vessels moved further offshore. Catches of blue whales peaked in the 1922/1923 season, while those of fin whales peaked nearly a decade later in 1929/1930 (Allison, 2020). Fin whales were subsequently the predominant catch at South Georgia from the 1940s to the 1960s. This later pattern of exploitation may explain why the two species are still uncommon in South Georgia coastal waters now, although blue whales, exploited earlier, are now being sighted more regularly offshore (Calderan et al., 2020). Reductions in nearshore habitat use due to southward shifts in krill distribution may also have an influence on whale distribution in the area (Atkinson et al., 2019). This could be particularly important for larger sized baleen whale species such as fin and Antarctic blue whales which rely on large, dense aggregations of krill for efficient feeding (Goldbogen et al., 2012, 2015; Miller et al., 2019). Another consideration is that krill-feeding fur seals, now very common in the coastal waters of South Georgia (Boyd, 1993), were virtually extirpated by sealing prior to the 20th century, and would have been very uncommon at the point when whaling began in 1904 (Hoffman et al., 2011). This may have reduced nearshore competition for available krill swarms at South Georgia, and explained the nearshore presence of these large krill feeders (Hart & Edmundson, 2017).

Over 50 years after whaling ended, local surveys, coupled with large-scale surveys and trends in visitor sightings (Baines et al., 2021; Jackson et al., 2020) confirm the return of humpback whales to nearshore waters at South Georgia. The current survey was limited to the summer period of January and February. However, the highest numbers of humpback whale catches in Cumberland Bay in 1905 occurred in March when 24 were captured (Hart, 2021) and catches in subsequent years were often highest in the austral spring (November to January; Hart & Edmundson, 2017; Hinton, 1925). Future surveys during these periods will help to better characterize the temporal spread of recovery, as well as the potential for overlaps with shipping.

This recovery has occurred in tandem with increasing tourist numbers, with cruise ships visiting Cumberland Bay nearly daily during the summer months (International Association of Antarctica Tour Operators, 2020). Our surveys suggest humpback whales are now present to the level where there may be at risk of vessel strikes, as highlighted by Leaper et al. (2021). Further studies are therefore urgently required to better understand the habitat use patterns of humpback whales in coastal waters. The International Association of Antarctic Tour Operators recently agreed to limit vessel speeds and use marine mammal observers when traveling through sites that are hotspots for visitors to the Antarctic Peninsula (Antarctic Treaty Consultative Meeting, 2019); the Government of South Georgia and the South Sandwich Islands is now trialing voluntary limits on vessel speeds at South Georgia, beginning in the summer 2022/2023 season.

The return of humpback whales to South Georgia in large numbers is a positive sign, and also an impetus for new scientific research, to understand the level of impact of the returning whales as significant krill consumers within the local marine ecosystem, and to consider this information in future management of the krill fishery by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Government of South Georgia and the South Sandwich Islands. South Georgia is home to a number of krill predators (including fur seals and penguins) which also forage in coastal waters in summer, due to the need to provision young animals on land. The impact of coforaging whales on these species is uncertain. Foraging whales may make krill more available to other predators by changing swarm behavior, for example breaking up swarms and changing their depth distribution (e.g., Urmey & Benoit-Bird, 2021). However, they also have a high total krill demand (recent estimate 3–3.8 million tonnes in the Scotia Arc; Baines et al., 2021), so in years when local krill are limited, there is potential for competition between these species. In contrast to local predators, whales can forage over very broad areas in the Southern Ocean however, and we hypothesize that when local krill are limited at South Georgia, humpback whales are likely to use other areas of the Scotia Arc to feed and be much less frequently seen in South Georgia coastal waters. Interspecies competition at local scales would be reduced, therefore. Systematic multiyear monitoring of coastal whale densities is required to properly assess this hypothesis, and to help understand the long-term impact of whale presence on local krill stocks.

## AUTHOR CONTRIBUTIONS

**Jennifer Jackson:** Conceptualization; data curation; funding acquisition; investigation; methodology; project administration; writing – original draft. **Amy S. Kennedy:** Investigation; methodology; writing – review and editing. **Connor Bamford:** Investigation; visualization; writing – review and editing. **Ian Hart:** Writing – review and editing. **Stephanie Martin:** Investigation; writing – review and editing. **Darryl MacDonald:** Investigation; writing – review and editing. **Michael Moore:** Writing – review and editing. **Emma Carroll:** Conceptualization; funding acquisition; investigation; methodology; writing – review and editing.

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