LaRGE 2026

Landslide Risk & Geo-Education

27 APRIL – 3 MAY 2026

FIELD TRIP GUIDE:
Piopiotahi Milford Sound – An exploration of societal risk to landslide-induced tsunami

Tuesday 28 April 2026

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Overview

This one-day field trip will visit one of New Zealand's most iconic and popular tourist sites and explore what is arguably one of the most complex landslide risk case studies in Aotearoa. With around 1 million domestic and international tourists visiting Piopiotahi Milford Sound each year, the fiord is undeniably an essential component of New Zealand's tourism industry. However, its location at a major plate boundary and the presence of more than 20 large landslide deposits on the bottom of the fiord suggest a high potential for landslide-induced tsunami. This field trip will explore Milford Sound by land and sea, exploring the physical setting and locations of major pre-historic landslides, potential tsunami inundation zones and evacuation paths, and hearing varying perspectives on the level of risk and how to manage it.

During our cruise on the fiord, you will hear perspectives on this risk and the implications for Aotearoa New Zealand from landowners, emergency managers, tourist operators, and scientists. The intent is to outline the high complexity of the situation and the difficult risk management decisions it presents. We are looking forward to engaging in a lively debate with all participants about the level of risk at Milford Sound, how best to manage and reduce that risk, and what other locations around the world can learn from our experiences.

The field trip will depart Queenstown at 0630 to visit Milford Sound via the scenic State Highway 94 and Te Anau. We will undertake a 2-hr private cruise in Milford Sound onboard the 'Sinbad' with RealNZ and explore the onshore village area before returning to Queenstown via the same route, arriving back at approximately 1900.

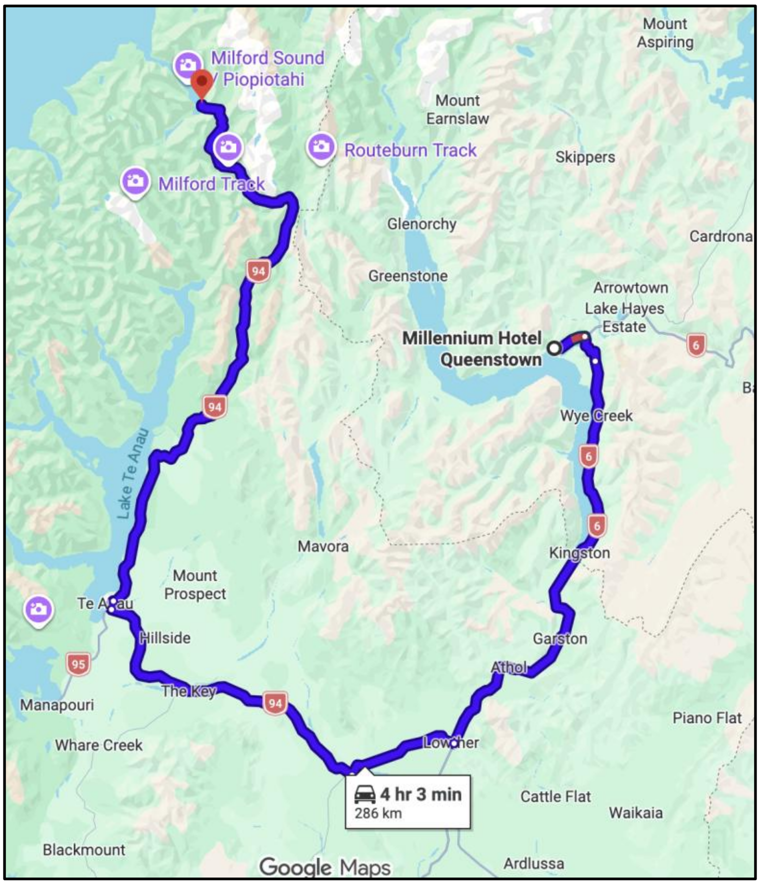

Figure 1 | Field trip route from Queenstown to Piopiotahi Milford Sound. We will take a short rest break at Te Anau on the way to and from Milford Sound.

Geologic and Tectonic Setting

New Zealand's South Island straddles the tectonic boundary between the Australian and Pacific plates. To the southwest, this plate boundary takes the form of the Puysegur subduction zone, where the Australian Plate subducts eastward beneath the Pacific Plate. To the northeast, the direction of subduction switches, with the Pacific Plate subducting westwards under the Australian Plate at the Hikurangi subduction zone. In between, the Alpine Fault accommodates this change in subduction direction via oblique right-lateral motion, forming the onshore section of the plate boundary. The Alpine Fault emerges onshore at the mouth of Milford Sound and runs for >600 km to the northeast at the foot of the Southern Alps (Fig. 2).

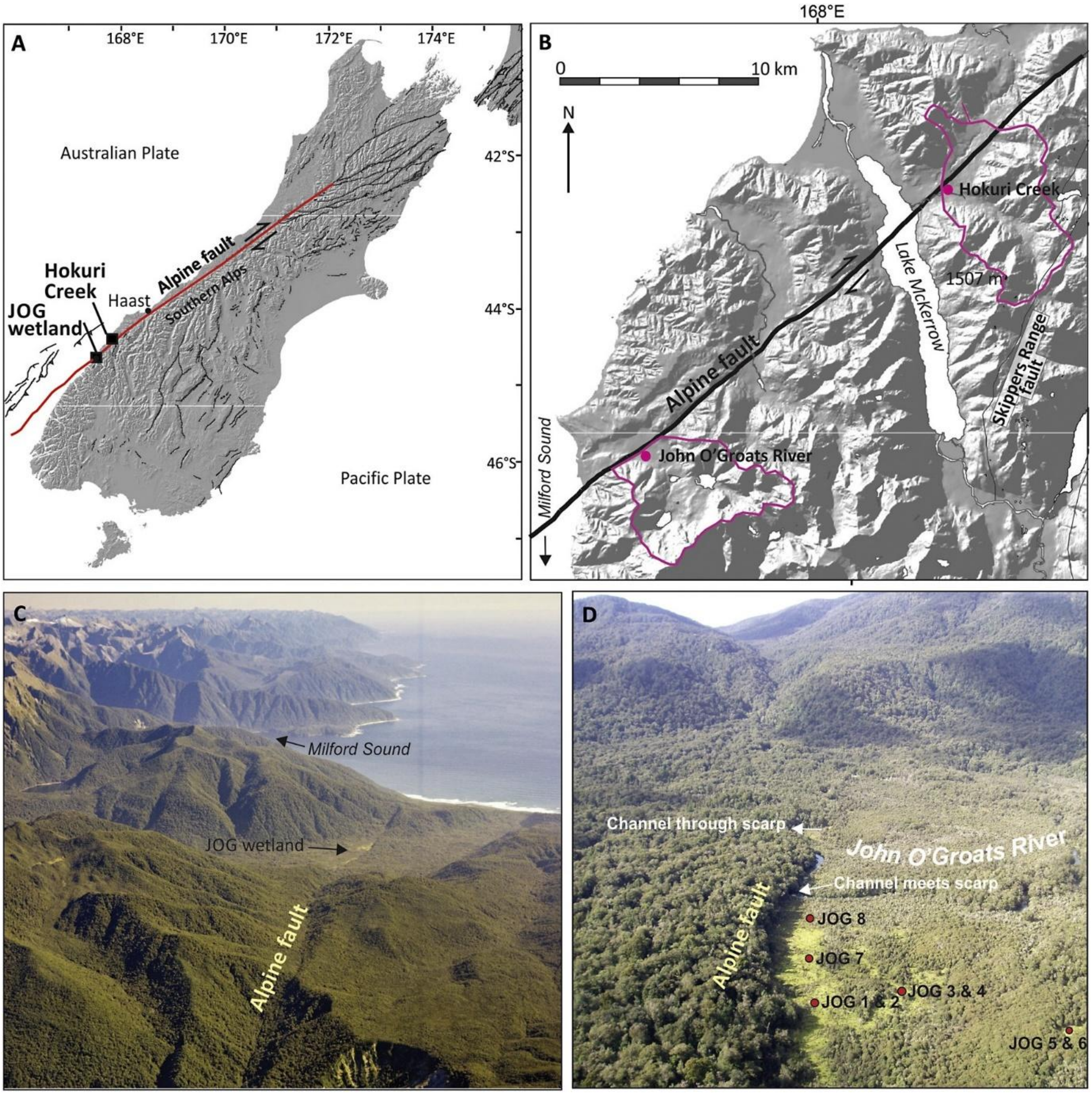

Figure 2 | Tectonic setting of the South Island showing the location of the Alpine Fault relative to Milford Sound and the John O'Groats and Hokuri Creek catchments where studies have dated earthquakes on the Alpine Fault going back 8000 yrs. Figure from Cochran et al. (2017).

The Alpine Fault accommodates around 70% of the plate boundary strain, accumulating an average of 30 mm per year of dextral slip and 6–10 millimetres per year of uplift. Evidence of the last 27 surface rupturing earthquakes on the Alpine Fault in the John O'Groats and Hokuri Creek catchments north of Milford Sound shows these events have all occurred in the last 8000 yrs (Berryman et al., 2012). Importantly, these dates show a highly regular pattern, with average recurrence intervals of ~300 years (Fig. 3). The most recent surface rupturing event has been dated to c. 1717 giving a 75% chance of an earthquake on the Alpine Fault in the next 50 years[1] (Howarth et al., 2021). Given current slip rates and previous single event displacement estimates of 2-3 m vertical and 8-9 m horizontal, it's thought likely such an earthquake will have M8+.

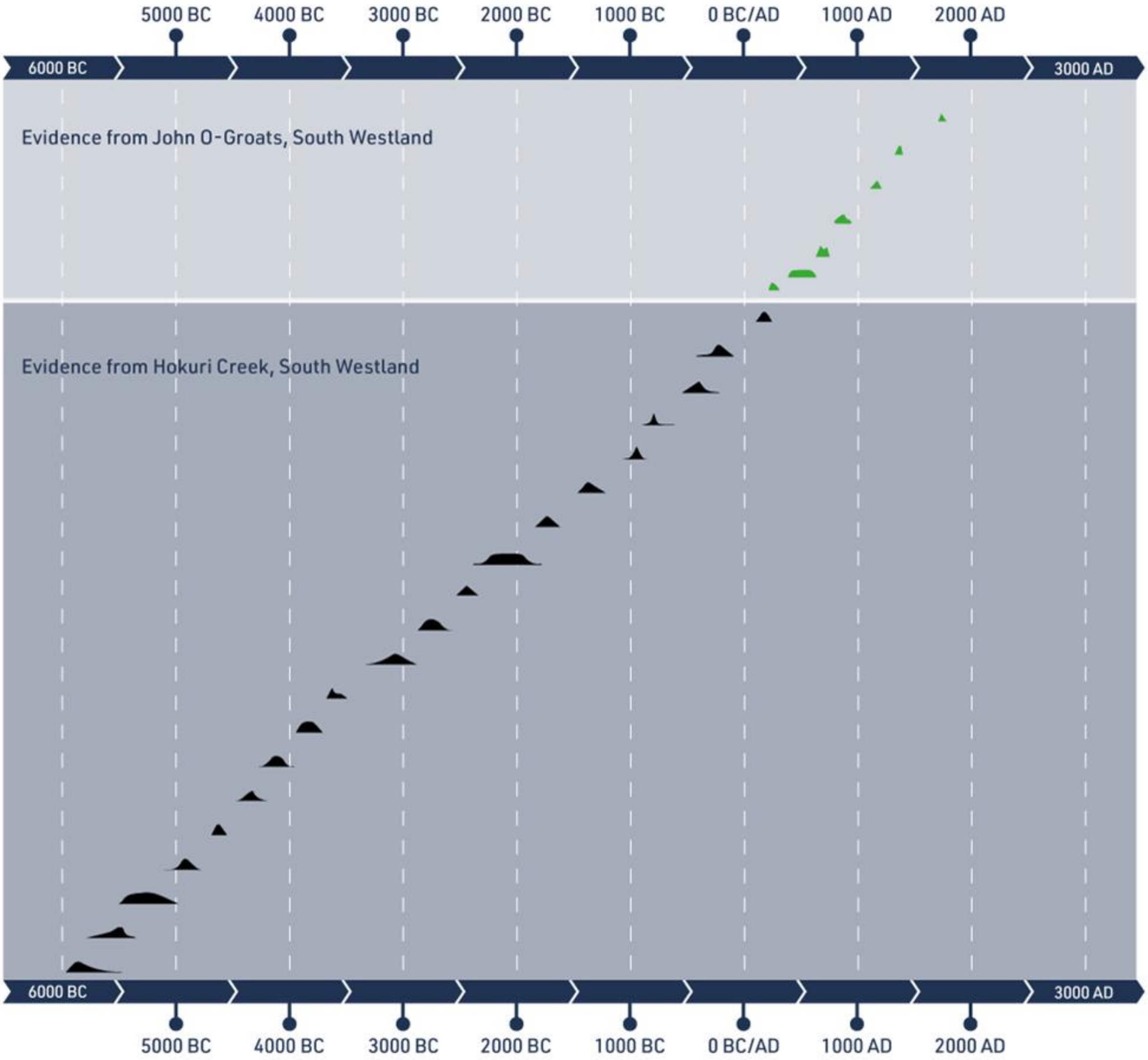

Figure 3 | Probability density functions for the timings of the previous 27 Alpine Fault earthquakes from south Westland (from Berryman et al., 2012). The regularity of previous earthquakes on this fault gives a 75% probability of an earthquake in the next 50 years.

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[1] For more information on New Zealand's planning for an Alpine Fault earthquake, visit the AF8 Project webpage at www.af8.org.nz

Piopiotahi Milford Sound

When is a sound not a sound…

Piopiotahi Milford Sound is located at the very north of Fiordland National Park, which along with Mt Aspiring National Park, Aoraki Mt Cook National Park and Westland National Park, makes up the Te Wāhipounamu UNESCO World Heritage Site. Milford Sound is approximately 17 km long and in places over 300 m deep, with the surrounding vertical cliffs, which extend up to 2000 m above the water, forming some of the tallest sea cliffs in the world.

Although named as a 'sound' by early European settlers, Milford Sound is in fact a fiord since it was formed by glacial erosion[2]. Over the past 2 million years, there were around a dozen major glaciations across the South Island with maximum ice thicknesses reaching up to 2 km. Exposure dates near the entrance to Milford Sound indicate that the main glacier had retreated about 9 km from its peak position by ~18 ka. Additional data suggest the main trunk glacier then receded rapidly over the next 2000 years, retreating a further 16 km to a position near the present-day confluence of the Tūtoko and Cleddau rivers ~3 km inland from Milford Sound village.

A 'Jewel' in New Zealand's tourism crown

Milford Sound Piopiotahi is one of Aotearoa New Zealand's most iconic landscapes, attracting more than one million visitors each year and contributing around $200 million annually to the regional economy. As the final creation of Tū Te Rakiwhānoa, it holds deep cultural significance alongside its World Heritage status. However, this growing popularity is also driving increasing exposure to natural hazards, as rising visitor numbers place more people within a dynamic and potentially hazardous environment, amplifying both the likelihood and consequences of disruptive events.

Between 2012 and 2018, visitation more than doubled, from approximately 437,000 to 883,000 people per year. Much of this growth was driven by day visitors travelling from Queenstown, often undertaking long return journeys of up to eight hours by road (much like us today). This pattern concentrates large numbers of people within narrow time windows and along a single access corridor of SH94, increasing vulnerability to hazards such as landslides, flooding, and road closures. As volumes of people increased, so too did the potential for disruption to cascade through the system, affecting not only visitor safety but also access, evacuation, and emergency response in this remote location.

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[2] By historical convention, all of Fiordland's fiords have retained 'sound' as their name (e.g. Milford Sound, Doubtful Sound, Charles Sound) making Fiordland, fiord-less…

In February 2020, this vulnerability was demonstrated during a significant and sustained weather event across Southland[3]. The resulting flooding, landslides, and widespread infrastructure damage severed SH94, leaving more than 600 visitors stranded in Piopiotahi. This event exposed the fragility of the single-access transport corridor and the concentration of people within it. In response, Emergency Management Southland were required to coordinate one of the largest air evacuations undertaken in New Zealand, highlighting the complex logistical challenges associated with managing large transient populations in remote, hazard-prone environments.

Recent data indicates that these exposure dynamics are not only continuing but intensifying. The 2025/26 summer has been one of the busiest on record[4], with strong growth in international visitation, particularly from Chinese markets, and increasing numbers of free independent travellers arriving by rental car and self-drive itineraries. Peak tourism periods, such as Chinese New Year, are extending high visitor volumes across longer periods, leading to sustained peaks in exposure. This results in greater numbers of people simultaneously present in hazard-prone locations, compounding congestion, limiting system flexibility, and increasing the potential consequences of natural hazard events in Piopiotahi Milford Sound. We will discuss and explore (and participate in…) these dynamics throughout this field trip.

Landslide-induced tsunami risk at Milford Sound

In the context of Milford Sound, landslide-induced tsunami risk is considered the potential for loss of life in a given period of time, calculated probabilistically as a function of hazard, exposure, and vulnerability. In order to understand the risk at Milford Sound, we need to understand each of these components (and their uncertainty) individually.

Landslide Hazard

The glacial history of Milford Sound has created a deeply incised glacial fiord surrounded by extremely steep (>45°) and tall (up to 2000 m) bedrock cliffs that plunge directly into the fiord. Onshore throughout Fiordland, landslide deposits are common, with the highest concentration around Milford Sound (Korup, 2005). This is largely attributed to extreme precipitation in the region, where annual totals can exceed 12 m, and the frequency of large earthquakes on the nearby Alpine Fault and Puysegur Trench. Earthquakes in 2003 (M 7.2) and 2009 (M7.8) each triggered hundreds of landslides across Fiordland. During the 2003 earthquake, a large landslide fell into nearby Charles Sound triggering a tsunami with run-up of 4-5 m.

At Milford Sound available seismic reflection data has identified a series of massive deposits of rock avalanche debris on the bottom of the fiord that can only have been deposited since deglaciation. At least 22 very large post-glacial rock avalanche deposits (Fig. 4) blanket ~40% of the fiord bottom (Dykstra, 2012). This corresponds to a rate of at least one very large rock avalanche into Milford Sound every 900 years, or one for every three Alpine Fault earthquakes. At least 10 additional very large-to-giant terrestrial landslide deposits have been identified in the lower Milford catchment (Fig. 4). Ages of 6 of these deposits correspond with known rupture dates on the Alpine Fault.

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[3] Southland Floods Response – Emergency Management Southland; https://storymaps.arcgis.com/stories/2e31928535604ed7b1f242ac5e382874

[4] Piopiotahi Milford Sound experiencing record summer: Media release 12 February 2026; https://www.doc.govt.nz/news/media-releases/2026-media-releases/piopiotahi-milford-sound-experiencing-record-summer/

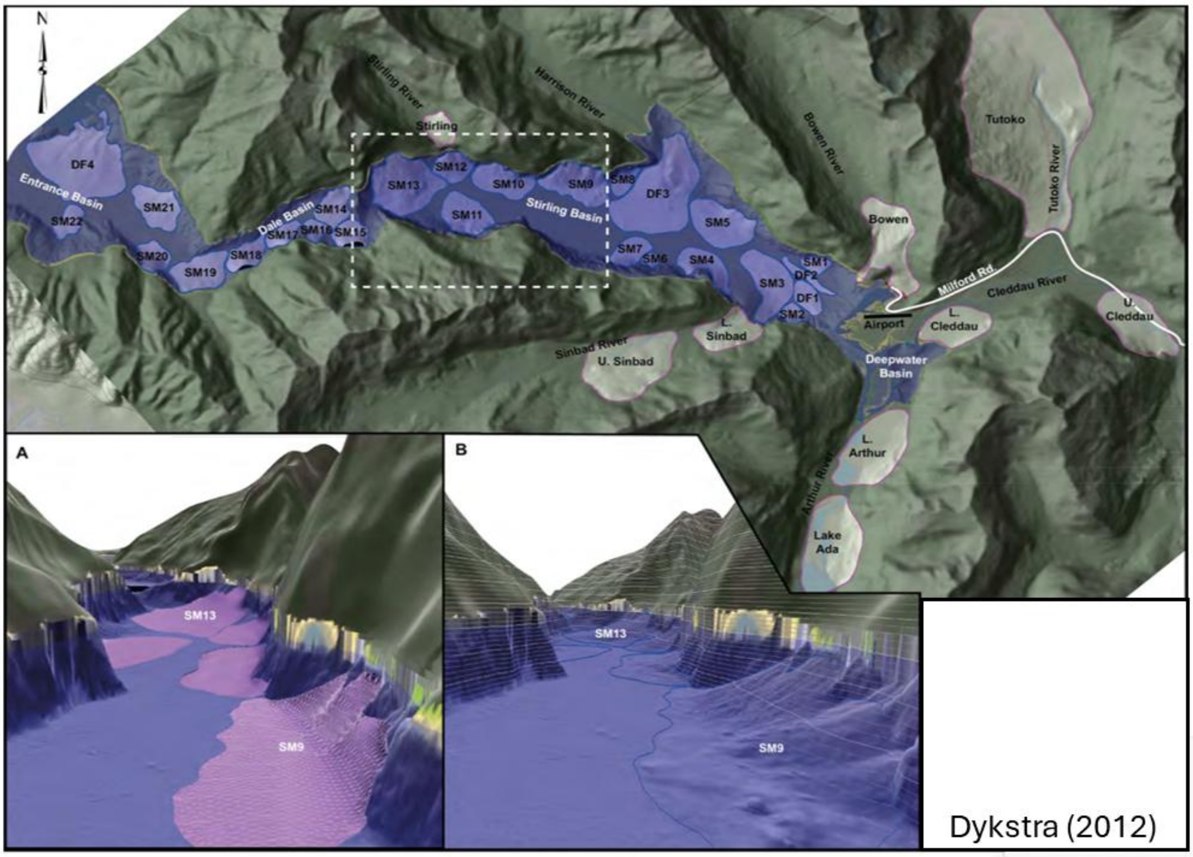

Figure 4 | Very large-to-giant submarine and terrestrial landslide deposits in and around Milford Sound. From Dykstra (2012).

Our cruise on this trip departs from the Milford Sound ferry terminal close to Bowen Falls and directly beneath on of these giant terrestrial deposits (Bowen rock avalanche deposit – 27 million m^3). Although hard to see clearly from the ferry terminal, we will get a good view of the source area for this rock avalanche during our cruise. Later in the cruise, we will visit Stirling Falls, which sits in between 3 source areas for submarine deposits and a large terrestrial rock avalanche deposit, as well as opposite the source zone for another deposit which fell from the famous Mitre Peak (Fig. 5). On our drive out we will be able to view the source zones and deposits for both the Lower and Upper Cleddau rock avalanche deposits on the true left of the Cleddau River, on our left-hand side as we enter Milford Sound. As we cross the single lane Tūtoko River Bridge, look out to the right (on the way in, left on the way out) and try to spot the source zone for the enormous Tūtoko rock avalanche.

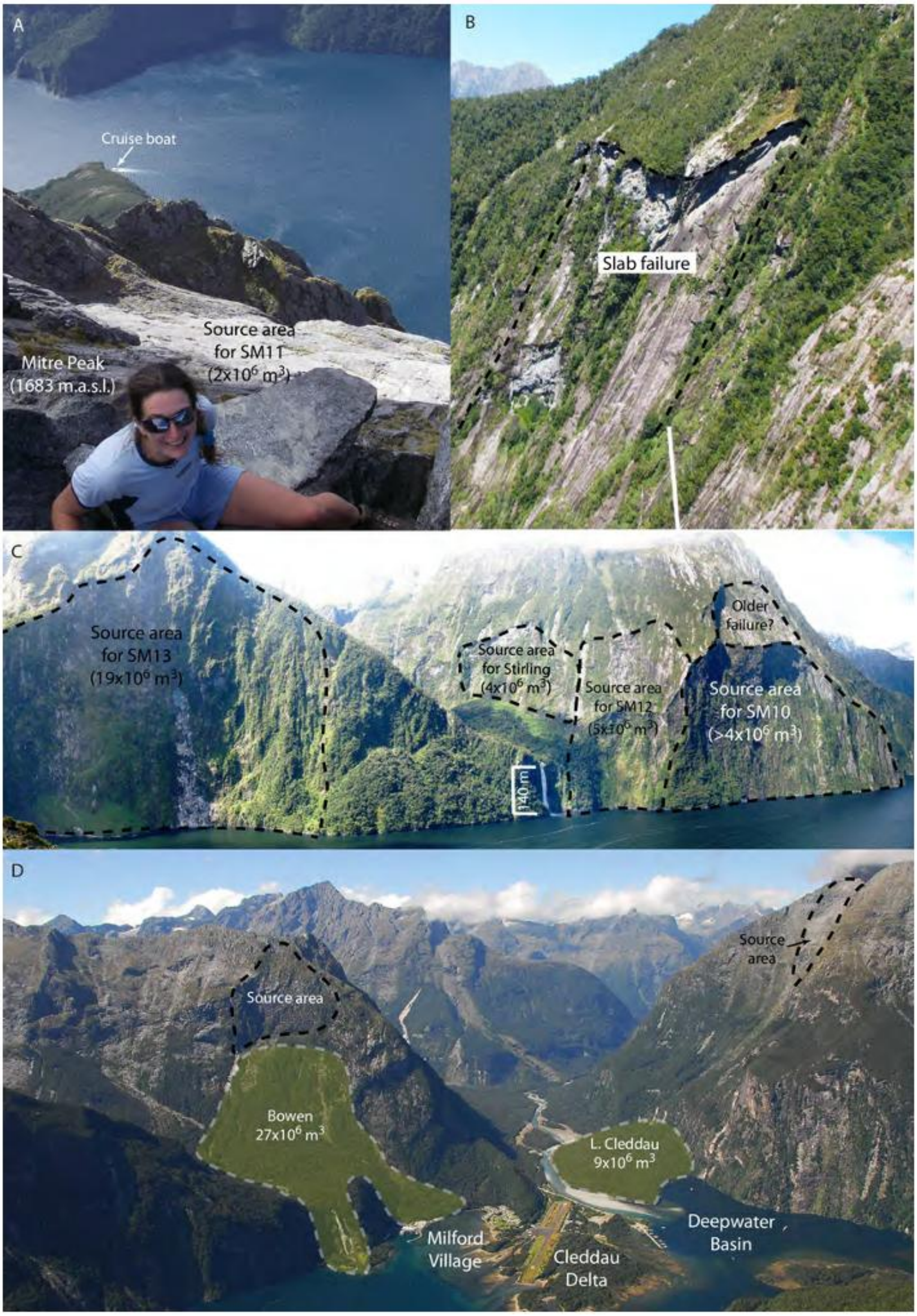

Figure 5 | Selected examples of rock avalanche source areas in Milford Sound. A) Mitre Peak opposite Stirling Falls. B) Relatively small slab failure source zone in the Harrison Valley. C) Source zones surrounding Stirling Falls. D) View of the enormous Bowen rock avalanche source and deposit and the Lower Cleddau rock avalanche. From Dykstra (2012).

Generation of a tsunami

Subaerial landslides entering a fiord, or submarine landslides within a fiord, can trigger large displacement waves with potentially devastating consequences. In Norway over the last 100 years, over 170 people have been killed by landslide-induced tsunami. The most dramatic of these was the 1934 Tafjord rockslide that generated a tsunami with a 62 m run-up that killed over 40 people. Perhaps the most (in)famous example is the 1958 Lituya Bay landslide-induced tsunami. Here, a M7.7 earthquake triggered a ~30 million m^3 rock avalanche into the fiord. This triggered a displacement wave that famously ran up the opposite valley wall to a height of 524 m (Fig. 6), making it the largest tsunami run up ever recorded. Maximum open-water wave amplitudes in Lituya Bay are thought to have approached 150 m, with the wave travelling at nearly 160 km/hr. At least one boat on the fiord at the time is reported to have been carried several kilometres out to sea by the tsunami. More recently in 2023, a giant rockslide in Dickson Fjord in Greenland triggered a 200 m high tsunami that had observable wave run ups over 100 km away. The seiching effects from this event were measured for the next 9 days (Svennevig et al., 2024).

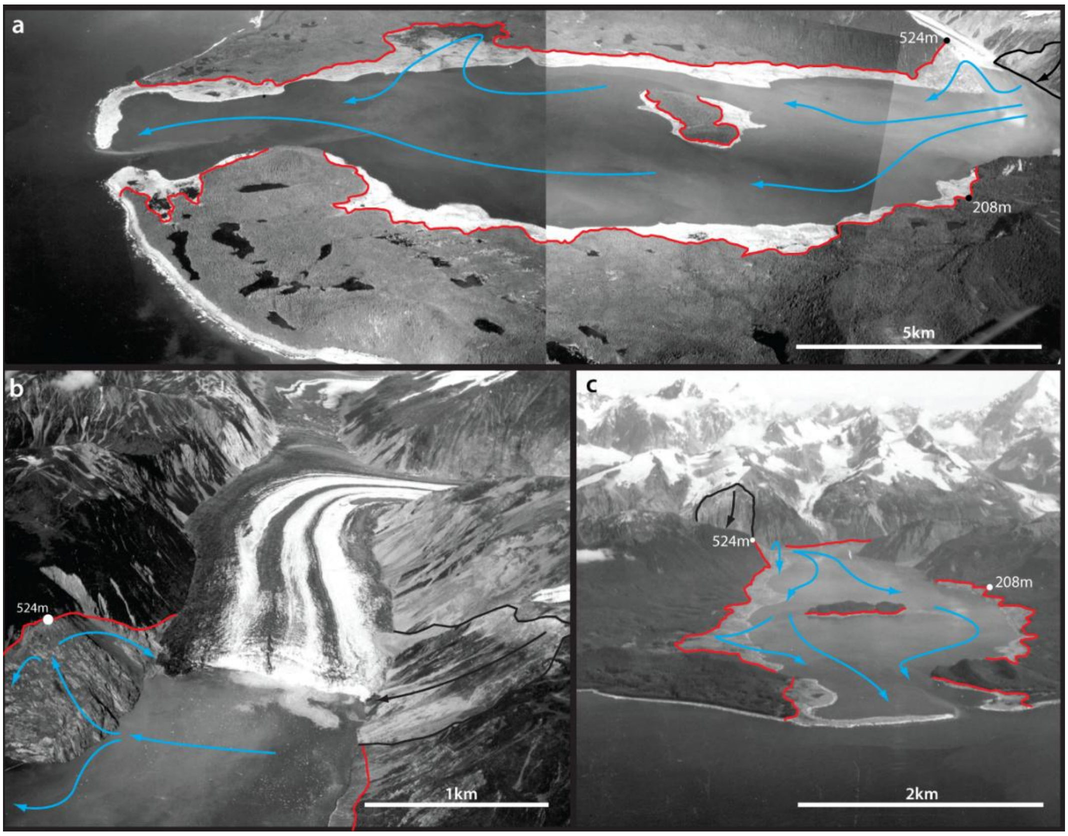

Figure 6 | Lituya Bay following the 1958 tsunami. (a) NW panoramic view of Lituya Bay and Centoaph Island; (b) NW view of Gilbert Inlet and Lituya Glacier showing landslide scar and wave run-up on spur opposite landslide; (c) NE view of Lituya Bay. From Robinson and Davies (2013).

Models of potential landslide-induced tsunami in Milford Sound are limited to empirical approaches based on global observations. Taig and McSaveney (2015) estimated that wave heights generated by the deposits on the bottom of Milford Sound could have ranged from 0.2 m to 82 m. However, accounting for wave attenuation within the fiord, the **largest wave height reaching the shore was**

estimated at 47 m. Based on published frequency-magnitude distributions for landslides in Fiordland, they estimate that **a 1-in-1000 yr landslide-induced tsunami in Milford Sound could have onshore runup of up to 17 m**. Depending on the precise location a landslide entered the fiord, the resulting tsunami is estimated to **reach the township within 2-7 minutes**. With 22 landslide deposits on the bottom of the fiord over a period encompassing ~50 Alpine Fault earthquakes, current estimates assume **a 44% probability of a landslide-induced tsunami in Milford Sound during the next Alpine Fault earthquake**. Given an estimated 75% chance of an Alpine Fault earthquake in the next 50 years, the annual likelihood of a landslide-induced tsunami in Milford Sound is thought to be ~0.66%[5].

Human vulnerability to landslide-induced tsunami

Numerous factors influence the vulnerability of individuals to tsunami. Dykstra notes an empirically determined vulnerability function from landslide-generated displacement waves in the Norwegian fjords and Alaska based on inundation height (Figure 6). Williams (2023) notes that it may be related to both the speed of the wave and demographics, with most 15 – 64-year-olds unable to remain standing in water speeds >1.2 m/s. In Milford Sound, potential wave speeds in the order of 30 m/s (Stantec NZ Limited, 2021) and 55 m/s (Dykstra, 2012) have been estimated, suggesting the chance of survival is close to 0 (or 100% fatality rate). In their recent assessment, Darling et al. (2025) assumed a conservative vulnerability index of 0.9 (90% of exposed people killed).

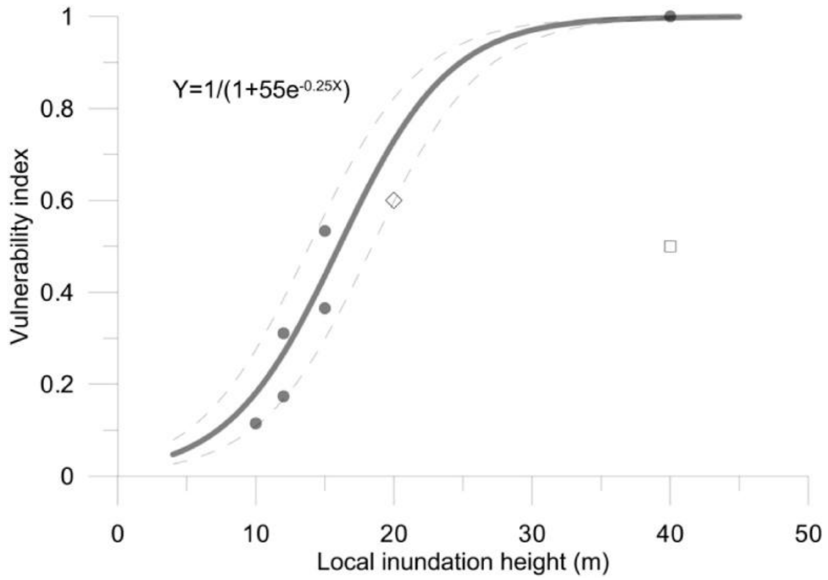

Figure 6 | Relationship between local tsunami inundation height (m) and the vulnerability index (portion of those exposed killed) in the Norwegian fjords and Alaska from Dykstra (2012). A 1-in-1000 year tsunami in Milford Sound has an estimated runup of 17 m, which translates to a vulnerability index of ~0.6 (60% fatality rate).

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[5] We will be spending ~4 hrs in Milford Sound, giving a **chance of this event during our stay of ~3×10^{-4} %** (0.0003%). We will highlight the tsunami evacuation sites to you when we arrive in Milford Sound…

Most studies on human vulnerability to tsunami only consider people on land. However, what remains uncertain is the vulnerability of people on cruise and fishing vessels exposed to such tsunami impacts. Muhari et al. (2015) provides empirically derived loss functions based on observations from the 2011 Tōhoku earthquake and tsunami, showing that vessels begin to experience a greater than 50% probability of severe damage at relatively modest wave conditions (~1.9 m height; ~2.1 m/s velocity). Under more extreme conditions, the likelihood of catastrophic loss increases rapidly, exceeding 90% for waves greater than ~8 m in height and ~5 m/s in velocity. However, this evidence is from a highly populated area of Japan, with associated infrastructure and significantly more debris in the tsunami wave than would be expected in Milford Sound. In Lituya Bay, at least one boat present in the fiord at the time is reported to have surfed the tsunami out into the ocean. Davies & Dykstra (2025) suggest that the vulnerability of people on vessels is likely to be on the order of 0.4 (40% of exposed people killed), implying that slightly less than half of those exposed may not survive under severe impact conditions.

Human exposure

Numerous studies have attempted to estimate the potential number of people likely to be exposed to a tsunami at Milford Sound. Based on cruise ticket sales data, Harris et al. (2024) showed there were strong seasonal trends in population exposure, with >3000 people visiting per day during the peak summer season, compared to <1500 per day during the winter season. However, most visitors only remain in the fiord for a few hours, typically arriving by coach and undertaking a boat cruise, with a short onshore stay (just as we are doing today). Taig and McSaveney (2012) assumed that just 10% of visitors but 100% of staff remained in Milford Sound overnight, equating to ∼500 people present overnight in the summer and <250 in the winter. Understanding how these numbers change during the daytime however is more challenging.

Darling et al. (2025) used Wi-Fi probe data at Piopiotahi Milford Sound to understand how the number of people present in the fiord changes through time. For >790 days (and counting), any active Wi-Fi capable devices were detected at the Milford Sound ferry terminal[6] and aggregated into 5-minute intervals (Figure 7), allowing an estimate of how many people were present at any given moment. They recorded a maximum of ~2000 individual devices in a 5-minute period, highlighting the large volumes of people that can congregate at the Milford Sound ferry terminal and potentially be exposed to tsunami, with most days in the record seeing >1000 people present at peak times. The data also show just how quickly this exposure can change, with a maximum 5-minute change in devices counted of ~1000 at one point in the study.

Throughout our time in Milford Sound, it is worth paying attention to how the number of people present fluctuates.

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[6] If you leave the Wi-Fi detection on your phone and/or tablet turned on during this field trip, you'll be anonymously counted in our ongoing data collection. Thanks for your participation!

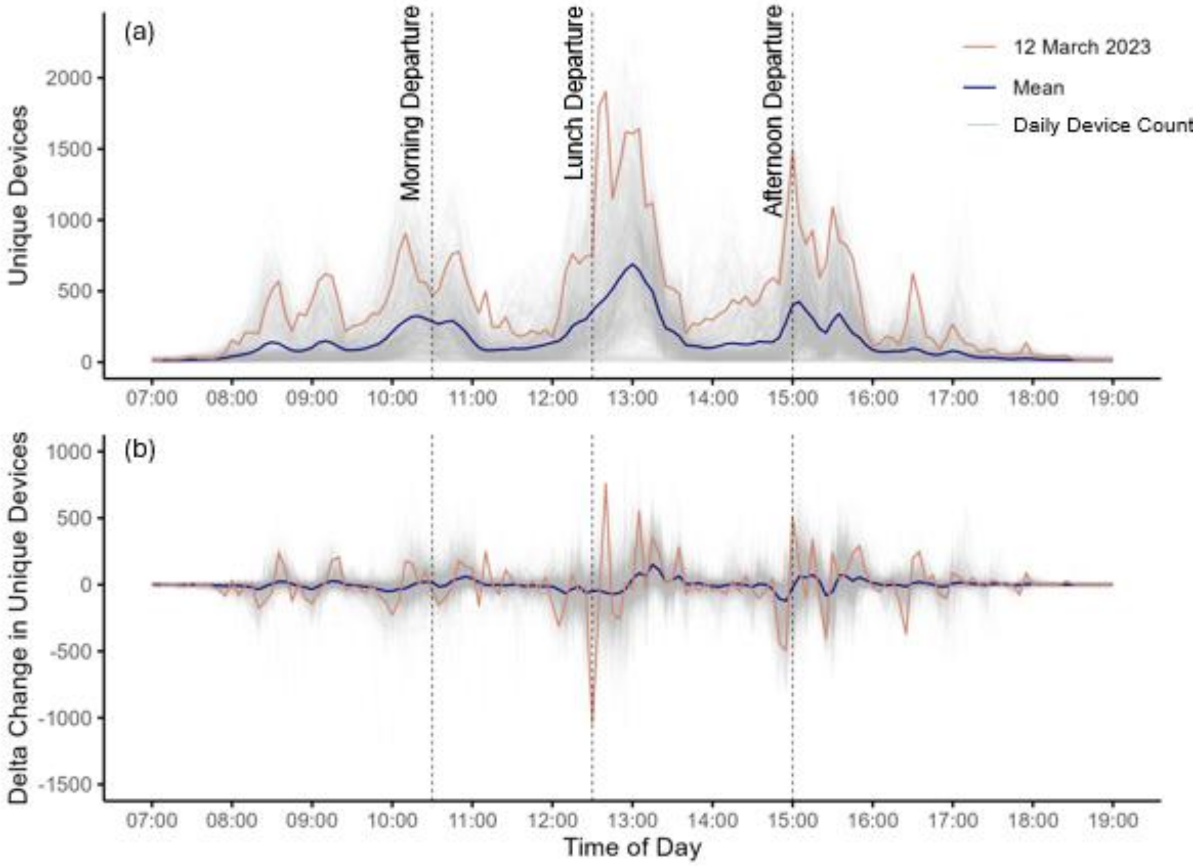

Figure 7 | Wi-Fi probe count (**a**) and change in devices (**b**) over the entire 790-day study period with the highest visitation date (12 March 2023) and mean highlighted. Each day in the record is shown as a grey line from Darling et al. (2025)

Risk at Piopiotahi Milford Sound

Using this understanding of hazard, exposure, and vulnerability, we are able to estimate the risk to individuals visiting Milford Sound and evaluate whether this risk is tolerable or not.

Individualised risk

Individual risk is the metric is the most appropriate for communicating risk to visitors, as it reflects the risk an individual personally accepts when choosing to undertake an activity[7].

There have been numerous attempts to calculate the individual risk for both visitors and workers at Milford Sound. Taig and McSaveney (2015) estimated the **annual individual fatality risk (AIFR)** for staff to be approximately **1.5 x 10^{-4} to 5.5 x 10^{-4} per year**, similar to that of those working in the mining or forestry sector. For a day visitor like us today, it was estimated to be approximately **1.0 x 10^{-6}**, similar to undertaking a bungy jump[8]. An overnight stay however, increased the AIFR to approximately **1.0 x 10^{-}**

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[7] Whether they are aware they are accepting this risk or not is something we will discuss during our trip…

[8] Which you can famously undertake when we return to Queenstown if this trip doesn't give you enough of an adrenaline kick!

[5]. More recently, Davies and Dykstra (2025) calculated the individualised fatality risk for a typical short duration visit and came to similar conclusions (on the order of **1.0×10^{-6} to 1.0×10^{-7}**).

Building on their dynamic population modelling, Darling et al. (2025) calculated the **fatality risk[9] (probability of one or more fatalities)** for each 5-minute period of the day. This produced a dynamic risk profile across the day, that varied from approximately **1.0×10^{-4} to 1.0×10^{-6}**, with peak periods of higher risk around the tourist cruise departure times, when large numbers of people congregate at the ferry terminal (Figure 8). This shows that risk at Milford Sound is highly dynamic and can vary by up to an order of magnitude, within very short timeframes.

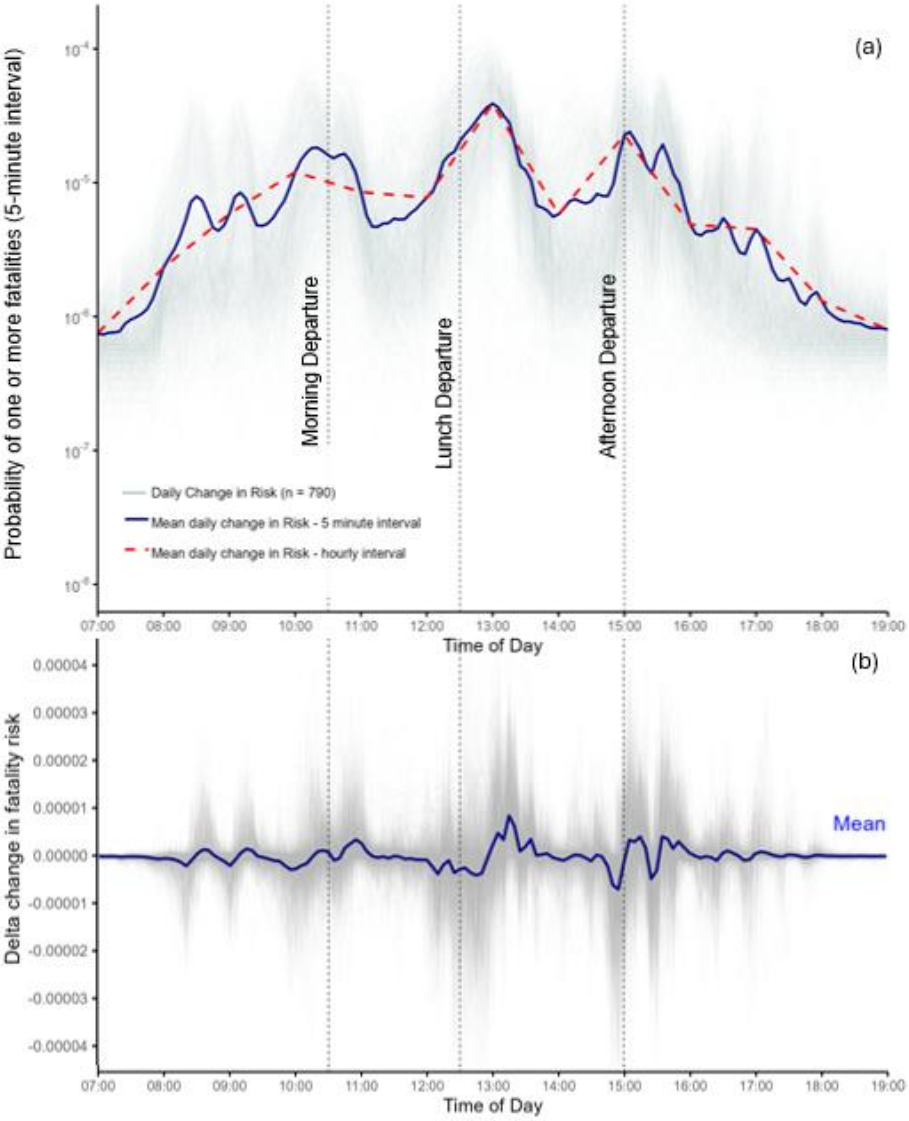

Figure 8 | (**a**) Diurnal cycles of recorded risk at Milford Sound Terminal. Where the risk as recorded at the terminal shown on day-by-day basis (grey), with the mean risk over hourly and 5-min periods shown in red and blue respectively. (**b**) Delta change in risk over a 24 h period, where every day is shown as a grey line, and mean shown in blue from Darling et al. (2025)

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[9] Note that AIFR and Fatality risk in this instance are not the same – AIFR considers the annual probability of any one person being killed during their time at Milford Sound, while fatality risk estimates the probability of 1 or more fatalities occurring within a given time period.

Risk Evaluation

For visitors to New Zealand public conservation land, individual fatality risk is generally on the order of 1×10^{-10} to 1×10^{-7} per day (or visit), with variation across locations and activities. Consequently, a visit to Milford Sound is notably higher risk for individuals than visiting most other public conservation land.

To evaluate whether this level of individual risk for visitors is tolerable, the Department of Conservation use risk thresholds that distinguishes between sites based on the typical visitor risk tolerance. This acknowledges that day-trippers on an organised group tour have very different risk tolerance from visitors that climb Aoraki Mt Cook. Piopiotahi Milford Sound is identified as a 'Lower-risk tolerance visitor site', where the visitor has no intention of taking life-threatening risks[10] and the risks at these sites are comparable to activities with minimal or no threat to life (Figure 9).

Using these criteria, **the risk to an individual visiting Milford Sound typically sits between the Moderate and Substantial categories and is viewed as generally tolerable** but requiring strong targeted messaging. However, Darling et al. (2025) showed that **at peak times the risk may approach the High category**, which is not tolerable for a lower-risk tolerance visitor site[11]. For workers, the risk may be considered tolerable but is on par with some of the highest risk jobs in Aotearoa New Zealand (mining and forestry).

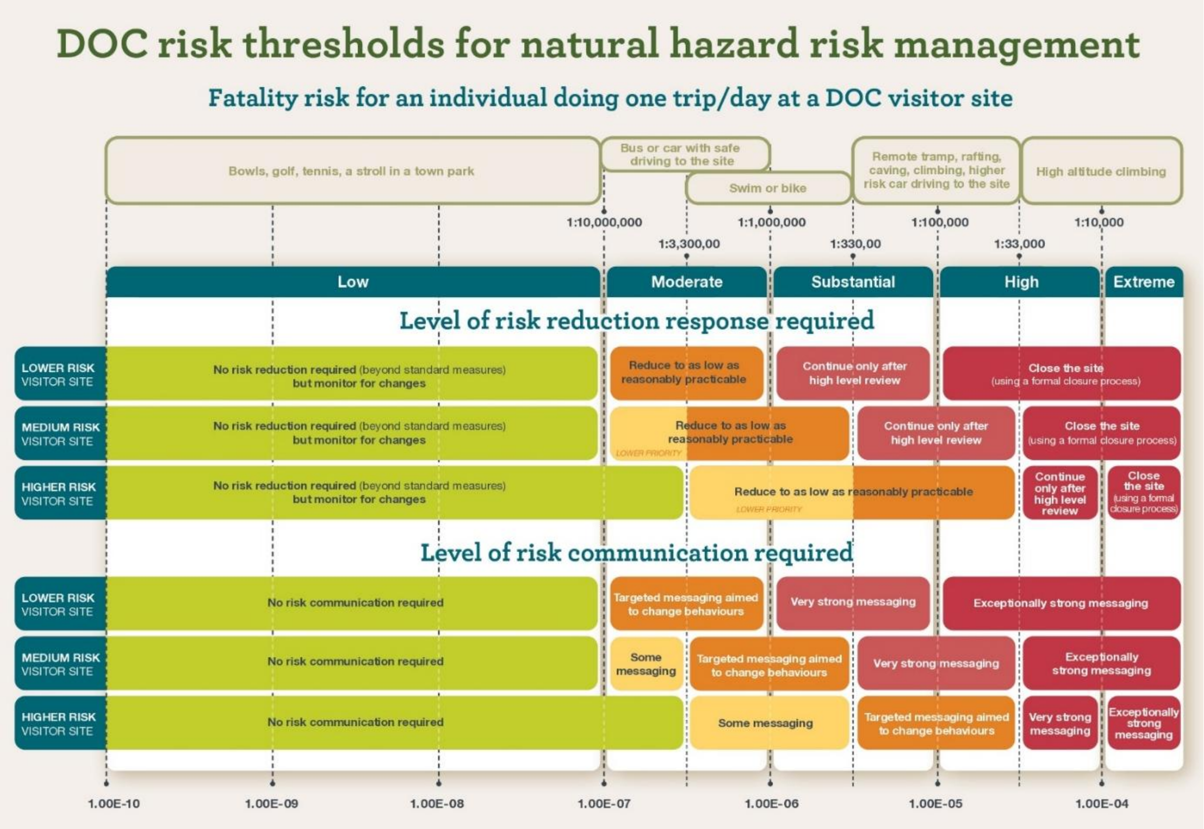

Figure 9 | Department of Conservation risk thresholds and suggested responses for different visitor risk tolerance sites. Milford Sound is classified as a Lower Risk Visitor Site.

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[10] Such as witnessing a landslide-induced tsunami…

[11] But is for a Higher-risk tolerance visitor site with very strong messaging.

Societal risk

Given the high vulnerability of people exposed to tsunami and the high daytime population exposure, a tsunami at Milford Sound has the potential to be a mass fatality event. Therefore, whilst individualised risk considers the risk to a single person, it is also important to consider the societal risk. Societal risk considers multiple deaths from one event as only tolerable to society if the event frequency is low.

Using their dynamic population data, Darling et al. (2025) showed that depending on the precise timing, **the number of fatalities at Milford Sound in a landslide-induced tsunami could vary between <10 and >1000** (Figure 10). The **frequency of such events varied between approximately 1 every 20 yrs and 1 every 1,000,000 yrs**. Critically, their observations covered the implementation and removal of COVID-19 restrictions in New Zealand, providing a unique insight into the effect of limiting exposure on risk. When the international border was closed and domestic travel restrictions were in place, both the frequency and number of fatalities dropped dramatically.

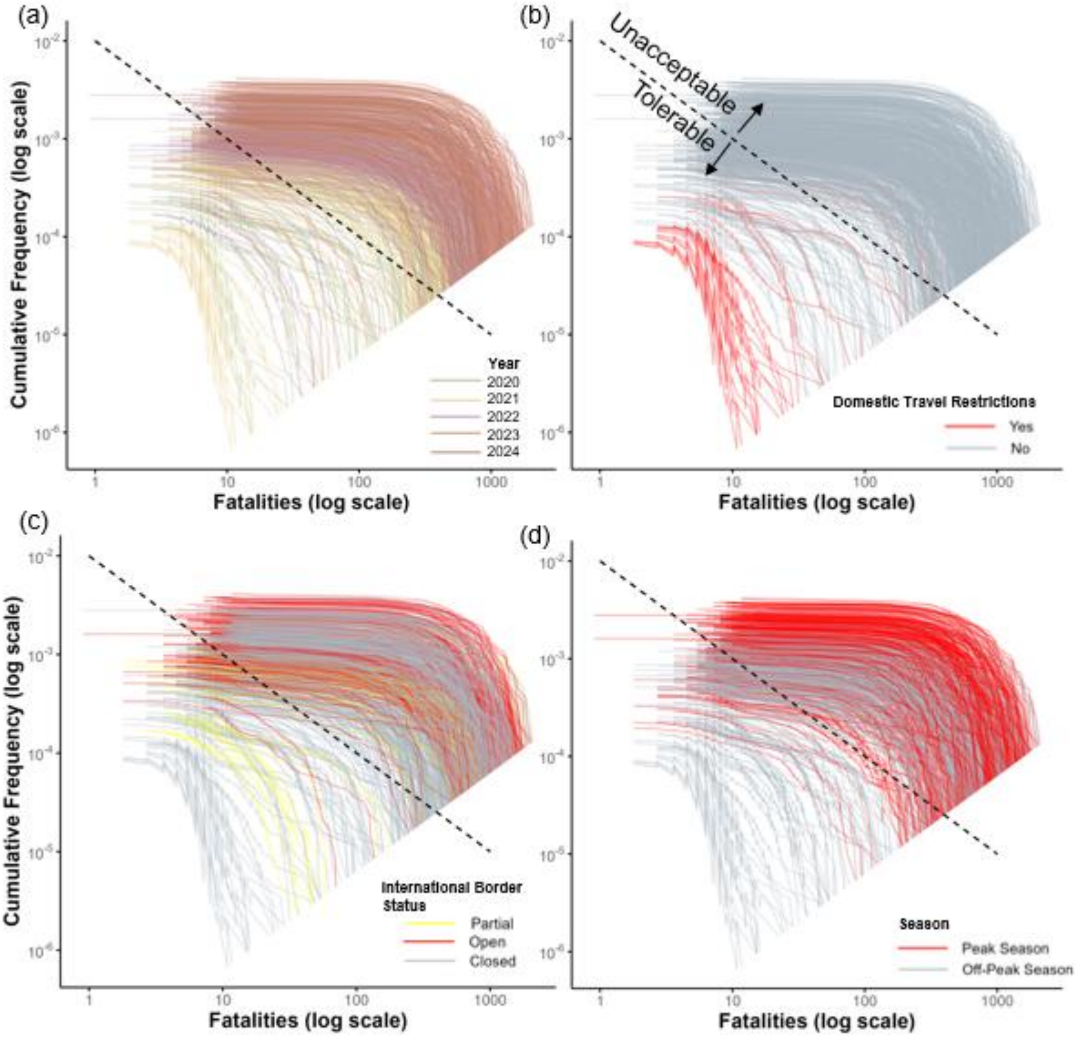

Figure 10 | Societal risk plots for Milford Sound, each line shows one day in the dataset with fatalities modelled every 5-mins based on the number of people recorded. The black dashed line represents the UK HSE societal risk tolerance threshold; values above the line are unacceptable levels of risk. Plots show the cumulative frequency of risk: (**a**) across the 790-day study period (from May 2020 until March 2024); (**b**) and (**c**) through the period of domestic and international travel restrictions implemented by the NZ Government during the Covid-19 pandemic; and (**d**) by tourism the season. From Darling et al. (2025)

However, in New Zealand there is currently no legislative framework for assessing societal risk and therefore no agreed risk tolerance threshold. Darling et al. (2025) therefore considered the UK's Health and Safety Executive societal risk tolerance, which considers the risk tolerable if >10 people are killed less than once every 100 yrs, >100 people are killed less than once every 1000 years, >1000 people are killed less than once every 10,000 years etc. The UK HSE threshold represents one of the least conservative thresholds globally thereby setting a low bar for acceptable societal risk.

At this level, Darling et al. (2025) show that **87% of the days in their study exceeded the UK HSE's societal risk tolerance threshold**. The 103 days where risk was below the tolerable threshold occurred when travel restrictions, including the closure of the international border, were employed by the New Zealand Government during the COVID-19 pandemic. **Since the removal of these restrictions and the increase in both domestic and international tourism, data indicates the daily risk profile is moving further away from tolerable levels[12].**

For an individual such as yourself visiting Milford Sound, the risk therefore appears to be (just) tolerable, however for New Zealand society, the risk at Milford Sound may already be unacceptable…

Risk Treatment Options & Awareness

Evacuation Modelling

Evacuation is generally accepted to be the best way to mitigate tsunami risk. Landslide-generated tsunamis however, offer a unique challenge for evacuation as they are characterised by extremely short wave arrival times – 2-7 minutes at Milford Sound. As a result, exposed populations are required to recognise natural warning signs and self-evacuate. However, as most visitors to Milford Sound are international tourists, it's questionable how many know what natural warning signs to look out for.

Taig and McSaveney (2015) found that for every metre in elevation gained up to 16 m above sea level, the chance of being killed by a tsunami in Milford Sound decreased by 11%. Above 16 m, every metre gained in elevation reduces the likelihood of being killed by a tsunami by 46%. However, the terrain and dense vegetation in Milford Sound evacuating to high ground difficult. Only two evacuation routes exists in Milford Sound: a short hike to the look out point above the visitor centre, or back along SH94. We will explore these options during our time exploring the village after our cruise on the fiord.

Harris et al. (2024) used an agent-based evacuation model to assess whether evacuation represents a suitable risk treatment for Milford Sound, considering multiple different exposure scenarios. The modelling showed that **evacuation is fundamentally constrained by extremely short warning times, with no scenario in which evacuees reach safety before the earliest wave arrival; even with the longest wave arrival times only <5% of exposed people able to reach safety** (Figure 11).

Critically, the study identifies that inability to evacuate is not a behavioural issue, but a structural one. The limited number, capacity, and accessibility of evacuation sites, combined with distance from key locations such as the ferry terminal and congestion effects, mean that **>95% of people are unable to evacuate in time.** The authors conclude that **evacuation is unlikely to be an effective risk reduction strategy in Milford Sound**.

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[12] Current estimates suggest visitation has only returned to 86% of pre-COVID-19 pandemic levels

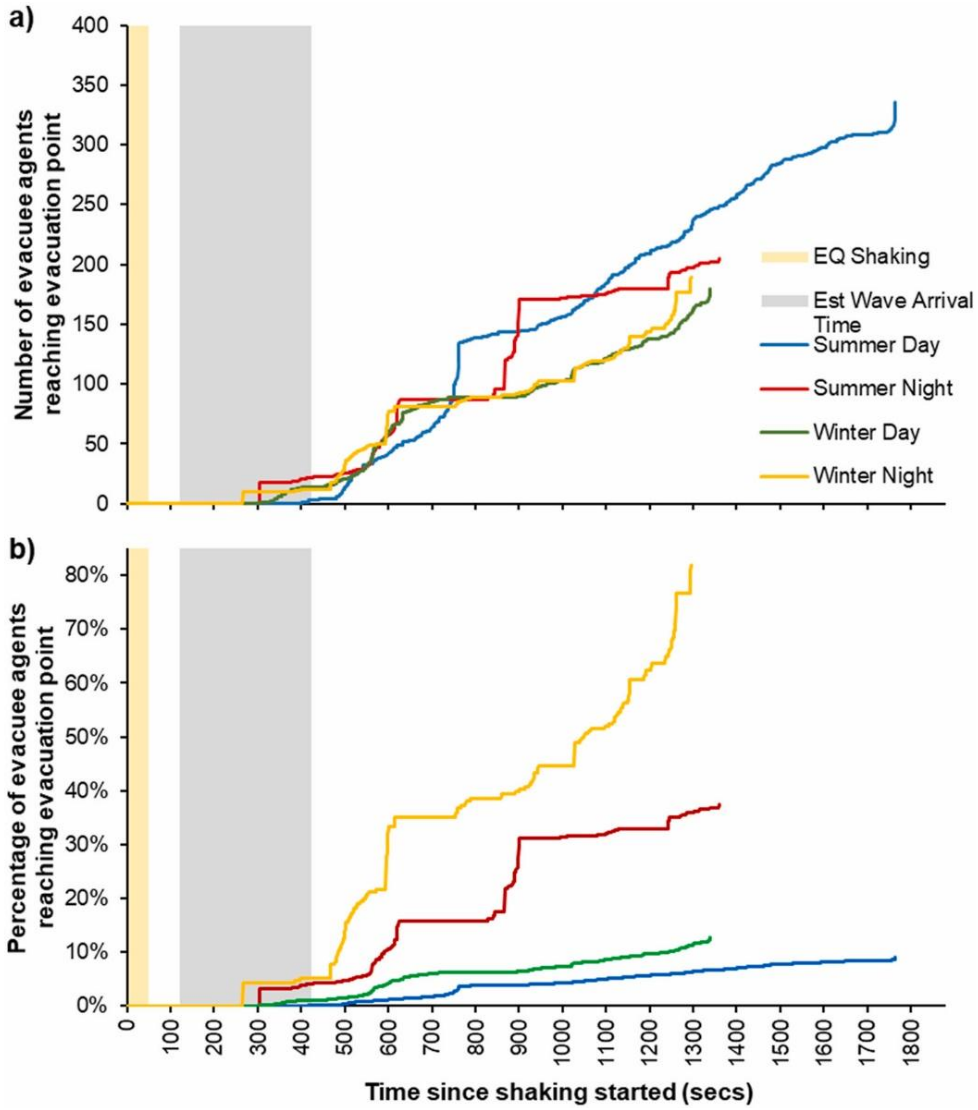

Figure 11 | Cumulative number of evacuees arriving at either evacuation point by season and time of day. Estimated tsunami wave arrival times are shown as grey vertical bar from 2 to 7 min, with earthquake shaking shown as yellow vertical bar from 0 to 45 s. From Harris et al. (2024)

Milford Sound in the media

Recent media coverage has increasingly brought the risk profile of Piopiotahi Milford Sound into sharp public focus, with a growing number of national outlets highlighting the potential for a high-consequence, mass-casualty event. Across 2024–2026, reporting has consistently emphasised the combination of large tourist populations, constrained evacuation options, and the potential for landslide- or earthquake-triggered tsunamis, often drawing explicit comparisons to events such as the 2019 Whakaari White Island eruption. This coverage increasingly positions Milford Sound not just as an iconic destination, but as a setting of concentrated and time-varying risk, where questions around acceptable risk, governance responsibility, and future management are now being actively debated in the public domain.

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Appendix A: Piopiotahi Milford Sound tsunami risk explainer

Piopiotahi Milford Sound:

A coordinated approach to understanding, communicating and managing natural hazard risk.

Piopiotahi Milford Sound is one of Aotearoa New Zealand's most iconic, stunning and remote visitor destinations. However, it's important visitors and workers understand the remote wilderness and dynamic geology that make this destination so incredible also present significant natural hazard risk, including earthquake-induced landslides and tsunami.

Research published by the University of Canterbury* has improved our understanding of this tsunami risk. However, further research to quantify, communicate and manage this risk is required. In response, Emergency Management Southland (EMS), in collaboration with Milford Sound Tourism Limited (MSTL), the Department of Conservation (DOC), the National Emergency Management Agency (NEMA), and other partners, have initiated a multi-stage project to improve our understanding of natural hazard exposure and quantify risk to life from tsunami hazards for both visitors and workers at Piopiotahi Milford Sound.

To support this, the project partners are also developing a collective hazard risk communication strategy to enable consistent messaging, and ensure people have the right information at the right time to make informed decisions regarding their safety.

Collective Hazard Risk Communication Strategy

While more research is needed to quantify and manage the risk of earthquake-induced landslides and tsunami at Piopiotahi Milford Sound, it is agreed that there should be no delay in communicating what we do know, and what we are doing to improve our understanding and management of the risk.

The Collective Hazard Risk Communication Strategy is based on advice from GNS Science and is designed to be implemented immediately. It includes short and medium-term actions to implement over the next 12-18 months, as the research progresses. It also includes a process for reviewing and updating as new science and hazard insights become available, to enable longer-term communications goals to be developed and implemented as our understanding of the risk improves.

Short-term actions	Medium-term actions	Longer-term goals
▸ Version one of strategy ready for implementation (Dec 2025 – Jan 2026) ▸ Agree consistent messaging updated across project partner websites with a focus on Milford Sound related content (Jan 2026) ▸ Staff induction tool built and online messaging updated (Jan 2026).	▸ Strategy reviewed and updated based on new tsunami modelling. ▸ Updates to online messaging accordingly. ▸ Ensure opportunities for mana whenua-led pūrakau to be communicated. ▸ Development of consistent messaging and narratives for use across physical touchpoints (e.g. signage).	▸ Strategy review and refresh of key messages based on new science modelling and risk analysis. ▸ Review of audience touchpoints based on updates to tourism destination plans. ▸ Updates to online messaging and physical touchpoints.

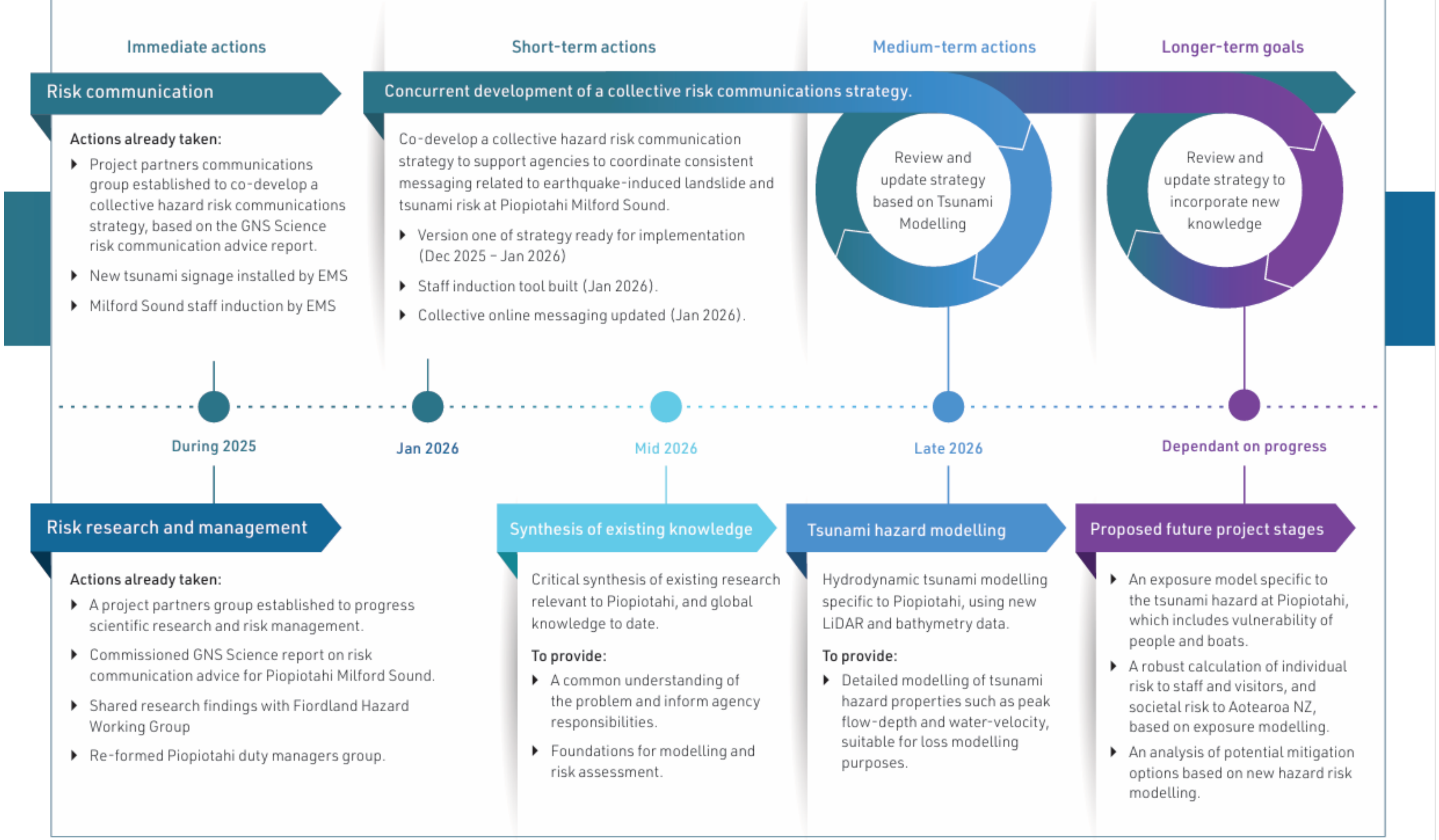
The strategy will:

- Establish a unified approach to how natural hazard risk associated with Piopiotahi Milford Sound is communicated.
- Enable the communication of clear and consistent risk messaging to support informed decision-making and the safety of staff and visitors.
- Be adaptable to new information, future science and organisational changes.
- Ensure hard risk messaging is underpinned by the most up-to-date science and modelling available.
- Improve risk literacy and build local hazard risk communications capability.
- Be able to take advantage of new technology and opportunities to share consistent messages.

Indicative project timeline

The graphic below summarises the two main workstreams: the science research required to quantify and manage the risk, and the development of a collective hazard risk communication strategy to guide a unified approach to communicating that risk.

It shows how the two workstreams align so new knowledge can be incorporated as the science research and risk modelling progress.



Risk communication

Actions already taken:

- Project partners communications group established to co-develop a collective hazard risk communications strategy, based on the GNS Science risk communication advice report.
- New tsunami signage installed by EMS
- Milford Sound staff induction by EMS

Concurrent development of a collective risk communications strategy.

Co-develop a collective hazard risk communication strategy to support agencies to coordinate consistent messaging related to earthquake-induced landslide and tsunami risk at Piopiotahi Milford Sound.

- Version one of strategy ready for implementation (Dec 2025 – Jan 2026)
- Staff induction tool built (Jan 2026).
- Collective online messaging updated (Jan 2026).

Risk research and management

Actions already taken:

- A project partners group established to progress scientific research and risk management.
- Commissioned GNS Science report on risk communication advice for Piopiotahi Milford Sound.
- Shared research findings with Fiordland Hazard Working Group
- Re-formed Piopiotahi duty managers group.

Synthesis of existing knowledge

Critical synthesis of existing research relevant to Piopiotahi, and global knowledge to date.

To provide:

- A common understanding of the problem and inform agency responsibilities.
- Foundations for modelling and risk assessment.

Tsunami hazard modelling

Hydrodynamic tsunami modelling specific to Piopiotahi, using new LiDAR and bathymetry data.

To provide:

- Detailed modelling of tsunami hazard properties such as peak flow-depth and water-velocity, suitable for loss modelling purposes.

Proposed future project stages

- An exposure model specific to the tsunami hazard at Piopiotahi, which includes vulnerability of people and boats.
- A robust calculation of individual risk to staff and visitors, and societal risk to Aotearoa NZ, based on exposure modelling.
- An analysis of potential mitigation options based on new hazard risk modelling.