

# Diving between continents: Visitor motivations, disturbance and management implications for Silfra, Iceland.

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## Introduction

The Silfra fissure in Iceland's Þingvellir National Park is a unique destination. It is the only place in the world where tourists can dive and snorkel in the crack between two continental plates. Dive and snorkeling entries into Silfra have increased dramatically during the last few years, and the potential for disturbance of both the fissure's ecosystem and the tourist experience requires monitoring and managing. This interdisciplinary study aimed to understand the motivations of dive visitors to Silfra and the impact of their dives. A mixed method approach to obtaining data from four key stakeholder groups included observation of divers; questionnaires completed by divers, tour guides and tour operators; and interviews with the Park managers. From the findings, management strategies to maintain the positive experience for divers while minimizing the negative impacts on the fissure are recommended.

## Study site

Famous for the tectonic processes that have created the water-filled rift valley of Lake Þingvallavatn, Iceland's Þingvellir National Park (ÞNP) contains several fissures between the North American and Eurasian continents filled with fresh groundwater. The Silfra fissure measures 373m in length at the surface, of which a 280m stretch is used for diving activities. Although mostly narrow (5-8m), Silfra ranges in width from 3 to 20m. The maximum depth in the part of the fissure open to the surface is 40m. A moderate current flows from north to south and at its southernmost end Silfra connects to Lake Þingvallavatn.

## Methods

To assess factors that influence motivations and experiences of diving in Silfra, in August 2015 we surveyed divers after their dive (n=61), operators of all major companies running diving tours (n=6), and dive guides (n=10). Respondents were asked to rank four factors (dry-suit diving, geology, biology or visibility) that influenced their decision to dive in Silfra and answer questions about their understanding of the im-

pacts of their dive. Þingvellir National Park officials were interviewed regarding the use of Silfra as a dive-site.

In September 2014 the underwater behavior of 35 divers was observed to assess the mechanisms and consequences behind diver-related ecological disturbances. The observer recorded each diver using a JVC GC-WP10 HD camera for five minutes while they were in the fissure. The videos were analyzed and the mechanisms of disturbances were counted and identified by source (fins, hands, equipment or body), target (algae or sediment), type (contact or current) and severity (minimal or severe).

## Results and Discussion

### *Motivations*

The main motivation for visitors who seek Silfra as a destination is its unique geology followed by its clear underwater visibility. Reputation may be largely responsible for this, as Silfra has been named in numerous dive-magazines and websites as one of the world's best dive sites. Guides considered visibility the most important and geology the second most important factor for their client's decision to dive in Silfra. Operators mostly focused on marketing visibility first and geology or biology of Silfra second.

Most divers did not consider biology an important factor in their decision to dive in Silfra and guides agreed, ranking biology as the least important factor for their clients decision to visit. This suggests that even if biological decay occurs in the fissure, it is unlikely to affect the popularity of Silfra as a tourism destination. Of greater concern to all stakeholders was overcrowding at the destination.

### *Disturbance*

During the five minute observation period, 91% of the 35 divers caused at least one disturbance. This is similar to ratios presented in studies on diver-related disturbances in marine systems, where the majority of observed divers were found to cause at least some disturbance (Barker & Roberts 2004; Luna et al. 2009; Uyarra & Côté 2007). Disturbance events averaged 11 per diver ( $SD=7.5$ ), and the total number of events observed was 373.

Most disturbance types occurred by diver-generated current ( $N=222$ ,  $mean=6.3$ ,  $SD=6.70$ ). Disturbance by divers direct contact with the algal cover or sediment were fewer ( $N=151$ ,  $mean=4.3$ ,  $SD=3.51$ ). The majority of disturbance mechanisms were fins ( $n=310$ ,  $Mean=8.9$ ,  $SD=7.76$ ), which accords with studies from coral reef dive-sites (Barker and Roberts 2004; Luna et al. 2009). Fins act as propellers for a diver and are moved quickly through the water, making them prone to disturbing the surroundings, either by contacting organisms or by generating a current resulting in the detachment of algae and the raising of sediment.

The duration of an average dive in Silfra is 38 minutes; therefore, each diver is estimated to cause 81 disturbance events, consisting of 50 algal removals and 31 sediment raising events. Although each diver may only cause relatively small disturbances, the cumulative consequences of multiple divers per day throughout each year could cause permanent damage to Silfra's ecosystem.

## Conclusion

Tourist numbers in Iceland are projected to increase, therefore understanding tourist motivations and experiences, as well as the impacts of and mechanisms behind diver-related ecological disturbance are important considerations in developing tourism management plans. As a consequence of fin-generated currents and direct contact, diver disturbance in Silfra results in the removal of algae and the raising of sediment. This ecological disturbance is likely to escalate with increasing numbers of divers. Management of the Park should include monitoring Silfra's biodiversity for changes that may occur as a result of increasing dive-use. Education programs to inform divers about appropriate fin technique and contact behaviour are also recommended.

Not all stakeholders valued ecological aspects of diving in Silfra equally, illustrating the importance of understanding these values better and implementing management strategies specific to diving in Þingvellir National Park. Analysis of stakeholder perceptions indicated that a further increase in visitor numbers may damage the tourism experience; therefore, consideration should be given to limiting the number of visitors allowed into Silfra. These management strategies could simultaneously reduce future ecological disturbance and enhance the quality of the tourism experience. To achieve this, future research should focus on establishing carrying capacities for fissure diving and snorkeling in Þingvellir National Park, and monitoring both visitor disturbance on ecology and satisfaction with experience.



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