The Glasgow Naturalist (2025) Volume 28, Part 4

https://doi.org/10.37208/tgn28402

Natural regeneration of the seagrass *Zostera noltii* in the Holy Loch, Argyll, Scotland

P. Rawlins & N. Hammatt*

Holy Loch Nature Reserve, Sandbank, Dunoon PA23 8PD

*E-mail: holylochnaturereserve@gmail.com

Seagrasses play a vital role in marine ecosystems by stabilising sediments, cycling nutrients, providing nursery habitat for fish and invertebrates, and capturing carbon (Nordlund *et al.*, 2016; Duarte, 2002). In the U.K., native seagrasses are mainly limited to *Zostera marina* and *Z. noltii*. These species have declined sharply over the past century due to coastal development, pollution, physical disturbance from anchoring and dredging, and disease outbreaks (Orth *et al.*, 2006; Jones & Unsworth, 2016).

Recent estimates suggest that over 90% of historic U.K. seagrass cover has been lost (Green *et al.*, 2021). The Holy Loch, a sea loch in Argyll, once a biodiverse marine habitat, was severely affected during the mid-to-late 20th century by the presence of a U.S. Navy submarine base. Activities associated with this facility, including dredging and chemical contamination particularly with copper, zinc and polychlorinated biphenyls (PCBs) (Miller *et al.*, 2000), plus agricultural and forestry run-off, are thought to have led to the local disappearance of seagrass beds.

Since the closure of the base in 1992, the loch has experienced gradual ecological improvement, though no active restoration of seagrass has been undertaken. This report details the findings of a 2025 survey that identified natural regeneration of *Z. noltii* within the Holy Loch. The first few stems were noticed in 2022. Since then, area expansion has occurred, and beds have become denser. Unlike most recent U.K. examples, which have relied on planting efforts (Gamble *et al.*, 2021), this regeneration appears to be spontaneous. The discovery contributes valuable insights into the conditions under which passive recovery may occur and underscores the importance of protecting such areas (Reynolds *et al.*, 2016).

Fieldwork was carried out between 12th and 17th May 2025, targeting the intertidal and shallow subtidal zones in the southeastern section of the Holy Loch. Approximately 20 ha of loch bed (Fig. 1) was surveyed by walking transects during low tide. Sediment type, vegetation cover, and visible signs of seagrass presence were recorded. *Z. noltii* was identified *in situ*, based on morphological features including narrow, linear leaves, a creeping rhizome system, and leaf sheath characteristics (Fig. 2). Observations were geo-referenced using handheld GPS devices (accuracy ±3 m), and photographic documentation was collected. No destructive sampling was performed. Spatial data were overlaid on aerial imagery using QGIS 3.34 to assess distribution and spatial coherence.

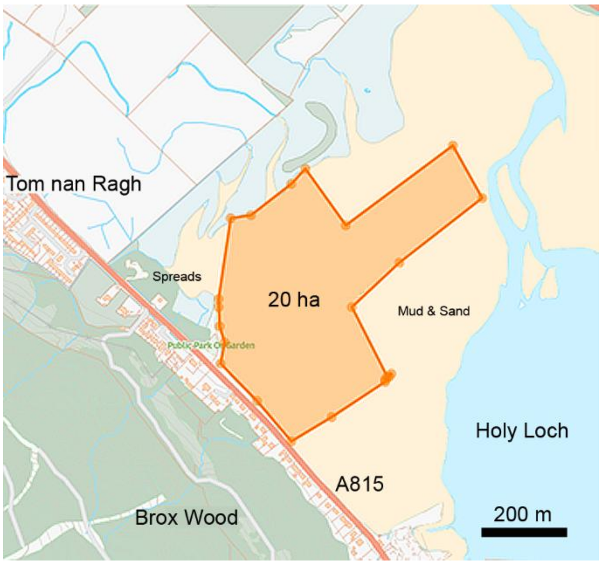

Fig. 1. Area of the Holy Loch seabed surveyed in May 2025. Field surveys focused on the southeastern intertidal and shallow subtidal zones. Approximate boundaries of the 20 ha search area are shown.

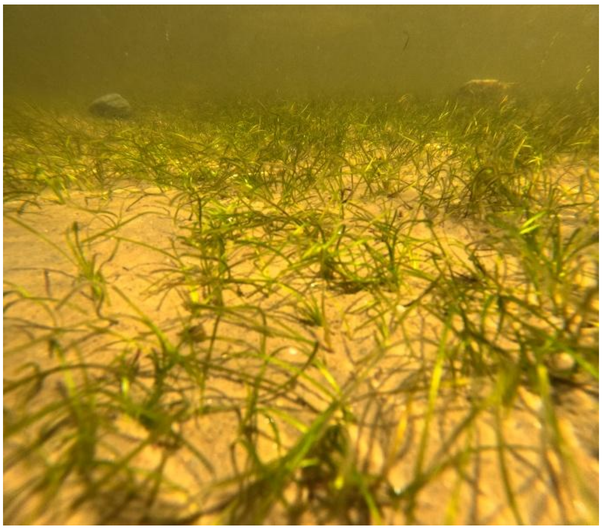

Fig. 2. Photograph of *Zostera noltii* on the bed of the Holy Loch, showing characteristic linear leaves. (Photo: N. Hammatt)

A continuous seagrass bed of approximately 3.6 ha was found southeast of the Holy Loch Nature Reserve (Figs. 3 and 4). Growth density varied, with the most robust patches observed in areas with minimal macroalgal competition and silty-sand substrates. Denser growth occurred in open patches free of other vegetation, while

Fig. 3. Aerial image of the head of the Holy Loch (May 2025), showing the locations of regenerating *Zostera noltii*. Red-shaded polygons represent the main bed, while red dots mark smaller, recently established colonies. (Photo: P. Rawlins)

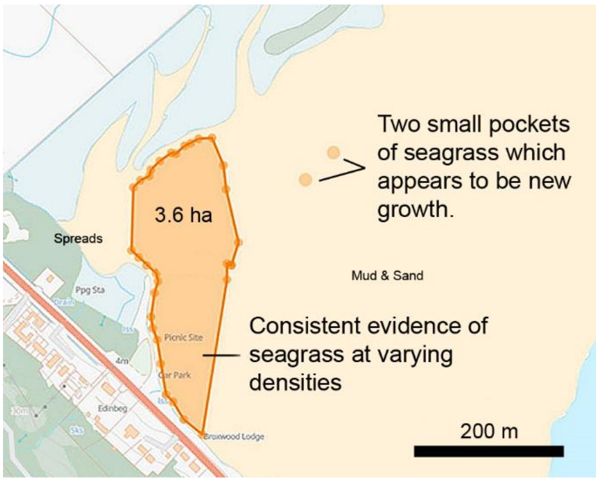

Fig. 4. Map showing *Zostera noltii* distribution at the head of the Holy Loch in May 2025. The main bed is highlighted in orange; smaller, newer colonies are marked as orange dots.

more fragmented patches were present in mixed-vegetation zones.

The eastern edge of the bed followed a depth gradient consistent with tidal exposure (Kendrick *et al.*, 2012). Two additional patches, each under 0.4 ha, were found northeast of the main bed (Fig. 4). These smaller patches exhibited signs of early-stage colonisation, including sparse rhizome spread and low shoot height (*ca.* 3-6 cm). All patch locations were recorded for future monitoring.

Water conductivity measurements have shown that this area of the seabed is subject to large fluctuations in salinity derived from varying volumes of rainwater run-off entering the loch during the year. Salinity measurements from the seagrass bed varied significantly from 9.5 PSU on 5th March 2025 to 42 PSU on 14th April 2025 after a relatively dry spell, which accords with the wide salinity tolerance of *Z. noltii* reported in the literature (see, e.g. d'Avack *et al.*, 2024).

The reappearance of *Z. noltii* in the Holy Loch represents a rare instance of natural seagrass recolonisation in a previously degraded coastal site. Given the loch's known history of industrial contamination and the absence of any planting activity, this finding is ecologically significant (Unsworth *et al.*, 2017). We hypothesise that dispersal from nearby lochs - such as Loch Long or Gare Loch - via tidal currents may have supplied viable propagules (Kendrick *et al.*, 2012). Additionally, a legacy sediment seed bank may have persisted in anaerobic conditions and responded to improved water and sediment quality (Jarvis *et al.*, 2014). Other, less likely, vectors include bird-mediated dispersal or long-distance drift from restoration sites such as Loch Craignish (Orth *et al.*, 2006).

The event highlights the resilience of *Z. noltii* and the potential for passive recovery in semi-enclosed lochs where hydrodynamic and environmental conditions are favourable (Reynolds *et al.*, 2016). The findings support the notion that some degraded systems retain latent ecological potential, which may be activated through environmental improvement alone. Continued monitoring is essential to determine persistence, expansion, and functional recovery of the meadow.

REFERENCES

d'Avack, E.A.S., Tyler-Walters, H., Wilding, C.M., Garrard, S.L. & Watson, A. (2024). *Zostera* (*Zosterella*) *noltei* beds in littoral muddy sand. In: Tyler-Walters, H. & Hiscock, K. (Editors). *Marine*

Life Information Network: Biology and Sensitivity Key Information Reviews. Marine Biological Association of the United Kingdom, Plymouth. https://www.marlin.ac.uk/habitats/detail/318/zostera_zosterella_noltei_beds_in_littoral_muddy_sand Accessed 3rd September 2025.

Duarte, C.M. (2002). The future of seagrass meadows. *Environmental Conservation* 29, 192-206. https://doi.org/10.1017/S0376892902000127

Gamble, C., Glover, A., Debney, A., Bertelli, C., Green, B., Hendy, I. *et al.* (2021). *Seagrass Restoration Handbook: UK & Ireland*. Zoological Society of London, London. https://cms.zsl.org/sites/default/files/2023-02/ZSL00168-Seagrass-Restoration-Handbook_20211108.pdf Accessed 3rd September 2025.

Green, A.E., Unsworth, R.K.F., Chadwick, M.A. & Jones, P.J.S. (2021). Historical analysis exposes catastrophic seagrass loss for the United Kingdom. *Frontiers in Plant Science* 12:629962. https://doi.org/10.3389/fpls.2021.629962

Jarvis, J.C., Moore, K.A. & Kenworthy, W.J. (2014). Persistence of *Zostera marina* L. (eelgrass) seeds in the sediment seed bank. *Journal of Experimental Marine Biology and Ecology* 459, 126-136. https://doi.org/10.1016/j.jembe.2014.05.024

Jones, B.L. & Unsworth, R.K.F. (2016). The perilous state of seagrass in the British Isles. *Royal Society Open Science* 3, 150596. https://doi.org/10.1098/rsos.150596

Kendrick, G.A., Waycott, M., Carruthers, T.J.B., Cambridge, M.L., Hovey, R., Krauss, S.L. *et al.* (2012). The central role of dispersal in the maintenance and persistence of seagrass populations. *BioScience* 62, 56-65. https://doi.org/10.1525/bio.2012.62.1.10

Miller, B.S., Pirie, D.J. & Redshaw, C.J. (2000). An assessment of the contamination and toxicity of marine sediments in the Holy Loch, Scotland. *Marine Pollution Bulletin* 40, 22-35. https://doi.org/10.1016/S0025-326X(99)00190-3

Nordlund, L.M., Koch, E.W., Barbier, E.B. & Creed, J.C. (2016). Seagrass ecosystem services and their variability across genera and geographical regions. *PLoS ONE* 11, e0163091. https://doi.org/10.1371/journal.pone.0163091

Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck, K.L. *et al.* (2006). A global crisis for seagrass ecosystems. *BioScience* 56, 987-996. https://doi.org/10.1641/0006-3568(2006)56[987:AGCFSE]2.0.CO;2

Reynolds, L.K., Waycott, M., McGlathery, K.J. & Orth, R.J. (2016). Ecosystem services returned through seagrass restoration. *Restoration Ecology* 24, 583-588. https://doi.org/10.1111/rec.12360

Unsworth, R.K.F., Williams, B., Jones, B.L. & Cullen-Unsworth, L.C. (2017). Rocking the boat: damage to eelgrass by swinging boat moorings. *Frontiers in Plant Science* 8, 1309. https://doi.org/10.3389/fpls.2017.01309