



**HAL**  
open science

## One Health on islands: Tractable ecosystems to explore the nexus between human, animal, terrestrial, and marine health

Nicholas M Fountain-Jones, Kate S Hutson, Menna Jones, Barbara F Nowak, Alison Turnbull, Jane Younger, Malgorzata O'Reilly, Emma Watkins, Vanina Guernier-Cambert, Louise Cooley, et al.

### ► To cite this version:

Nicholas M Fountain-Jones, Kate S Hutson, Menna Jones, Barbara F Nowak, Alison Turnbull, et al.. One Health on islands: Tractable ecosystems to explore the nexus between human, animal, terrestrial, and marine health. *Bioscience*, 2024, 10.1093/biosci/biae101 . hal-04898547

**HAL Id: hal-04898547**

**<https://hal.science/hal-04898547v1>**

Submitted on 20 Jan 2025

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

# One Health on islands: Tractable ecosystems to explore the nexus between human, animal, terrestrial, and marine health

Nicholas M. Fountain-Jones , Kate S. Hutson , Menna Jones , Barbara F. Nowak , Alison Turnbull , Jane Younger , Malgorzata O'Reilly, Emma Watkins, Vanina Guernier-Cambert , Louise Cooley  and Rodrigo Hamede 

Nicholas M. Fountain-Jones ([nick.fountainjones@utas.edu.au](mailto:nick.fountainjones@utas.edu.au)), Menna Jones, Malgorzata O'Reilly, and Rodrigo Hamede are affiliated with the School of Natural Sciences at the University of Tasmania, in Hobart Australia. Rodrigo Hamede is also affiliated with the Centre de Recherches Ecologiques et Evolutives sur le Cancer, Montpellier, France. Kate S. Hutson is affiliated with the Cawthron Institute, in Nelson, New Zealand, and with the Centre for Sustainable Fisheries and Aquaculture, in the College of Science and Engineering at James Cook University, in Townsville, Australia. Barbara F. Nowak, Alison Turnbull, and Jane Younger are affiliated with the Institute for Marine and Antarctic Studies at the University of Tasmania, in Hobart, Australia. Emma Watkins is affiliated with Biosecurity Tasmania, in the Department of Natural Resources and Environment Tasmania, in Hobart, Australia. Vanina Guernier-Cambert is affiliated with the IRD, INRAE, CNRS, UPEC, UMR iEES-Paris, at the Sorbonne University, in Paris, France, and with the Faculty of Veterinary Technology at Kasetsart University, in Bangkok, Thailand. Louise Cooley is affiliated with the Department of Pathology, Royal Hobart Hospital, Tasmania, Australia.

## Abstract

Islands play a central role in understanding the ecological and evolutionary processes that shape life but are rarely used to untangle the processes that shape human, animal, and environmental health. Islands, with their discrete human and animal populations, and often well-studied ecological networks, serve as ideal natural laboratories for exploring the complex relationships that shape health across biomes. Relatively long coastlines and, in some cases, low lying topography also make islands sentinels for climate change. In this article, we examine the potential of islands as valuable laboratories and research locations for understanding the One Health nexus. By delving into the challenges faced in island settings, we provide valuable insights for researchers and policymakers aiming to globally promote and apply One Health principles. Ultimately, recognizing the interconnected health of humans, animals, and the environment on islands contributes to efforts aimed at promoting global health and sustainability.

**Keywords:** antimicrobial resistance, oceans, infectious disease, arthropod-borne viruses, aquatic health

The concept of One Health has gained significant attention in recent years as a holistic approach to address the interconnections among human, animal, and environmental health (OHHLEP et al. 2022). The World Health Organization defines One Health as a unifying approach designed to sustainably balance and enhance the health of humans, animals, and ecosystems (WHO 2022). One Health approaches are increasingly used worldwide to address fundamental challenges such as antimicrobial resistance, ecotoxicology, pathogen spillover, and zoonotic pathogen dynamics (Mackenzie et al. 2014). For example, a One Health approach identified and controlled zoonotic schistosomiasis outbreaks in Corsica (Destoumieux-Garzón et al. 2018). Ecologists pinpointed the intermediate host, hybrid status, and Senegalese origin of the parasite; veterinarians confirmed the absence of ruminant reservoirs; and physicians and health authorities improved diagnostics, addressed patient clinical characteristics, and measured the outbreak's extent (Boissier et al. 2016, Destoumieux-Garzón et al. 2018). However, the environmental component of the One Health triad is often neglected, and this impedes progress in the field (Destoumieux-Garzón et al. 2018, Essack 2018, Muhammad-Bashir and Halimah 2022). Successful integration of the environment in One Health requires a reliable measure of ecosystem health. This is complicated because there is no generally accepted definition of ecosystem health (see Penn et al. 2024), and measures such as species richness that can be proxies for environ-

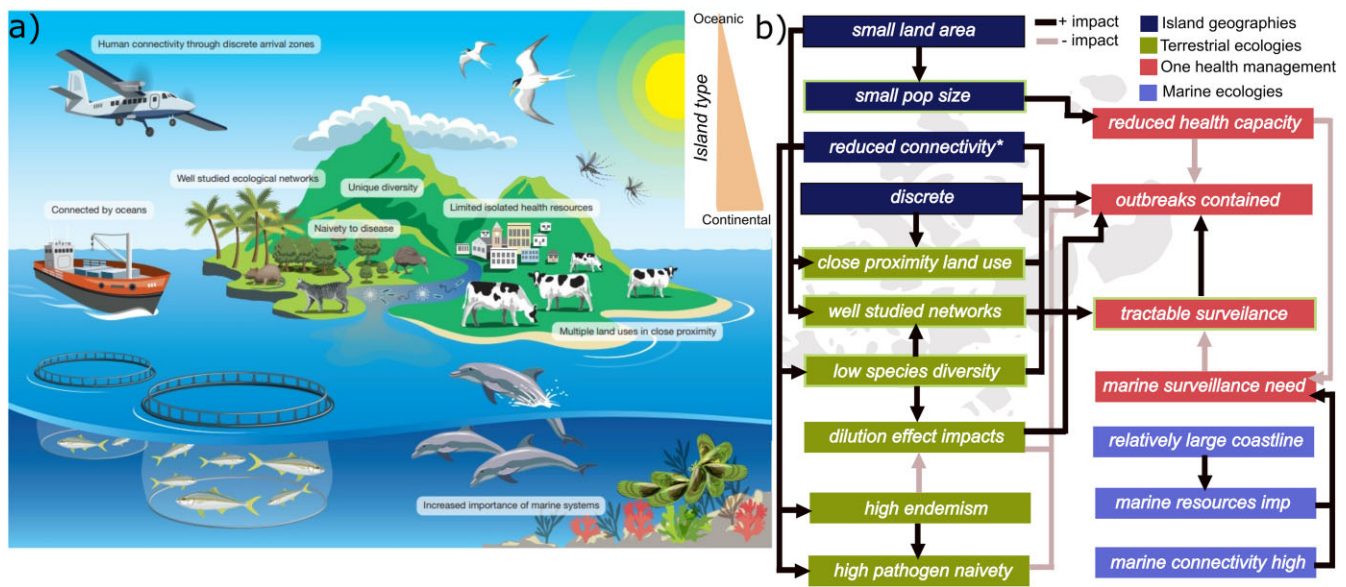
mental health are complicated by the fact that individual species distributions dynamically shift over large areas (e.g., Warren et al. 2015). Simply recording the number of species present at a location is difficult, particularly in the species rich tropics (Wiens 2023).

Although One Health principles have been applied globally, the unique characteristics and biota of islands provide tractable but underused ecosystems for exploring and implementing One Health approaches. Geographic isolation, land–sea interfaces, discrete human and animal populations with limited distributions, and (in some cases) well-studied ecological networks (e.g., Traveset et al. 2013, Cunningham et al. 2018, Harrison et al. 2020, Graham et al. 2023a) make islands ideal locations to better integrate environmental health with human and animal health. The convergence of multiple species—including humans; native and domestic animals; terrestrial, freshwater, and marine organisms—in limited space, creates opportunities for interdisciplinary research and interventions to address health challenges. Moreover, because islands are particularly vulnerable to climate change because of, for example, relatively large coastlines and, in some cases, low elevation (Veron et al. 2019, Leal Filho et al. 2024), they represent priority areas for One Health research.

Islands cover a broad gradient of human population sizes, socioeconomic development stages, and degrees of connectivity, from highly connected and developed countries such as the

Received: March 27, 2024. Revised: August 11, 2024. Accepted: September 3, 2024

© The Author(s) 2024. Published by Oxford University Press on behalf of the American Institute of Biological Sciences. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)



**Figure 1.** Conceptual figure outlining the One Health connections across islands. (a) Some of the aspects that make islands important laboratories for One Health research (Illustration: BirdCircus.com) and (b) how these island features may interact with One Health management. The plus sign indicates positive impacts (e.g., islands assist in outbreaks being contained), and the minus sign indicates negative impacts (e.g., high pathogen naivety hinders outbreaks being contained).

United Kingdom and Singapore to less developed but highly populated countries (e.g., Java) through to some of the most remote places on Earth (e.g., the Seychelles and the Polynesian islands). Broadly, islands can be classed as continental (i.e., located on a continental shelf) or oceanic (no geological connections to continents). Because the majority of islands have relatively low populations sizes compared with continental land masses (Moloni and Burns 2023), we focus on the less connected smaller marine island countries or states with populations less than 2 million people. This includes examples from both continental and oceanic islands, as well as small island developing states in the tropics that are identified by the United Nations as having distinct sociodemographic and sustainability challenges (UNCD 1994). Even within this subset of islands, development status and access to health resources varies, as do the particular One Health challenges (Mackenzie et al. 2014). Inadequate health resources, workforce capacity, and surveillance are key (and often linked) barriers for One Health approaches to be operationalized in developing islands and continental countries alike (Yopa et al. 2023). However, the isolation of islands magnifies these difficulties, because, for example, communities have to use slower sea transport to receive secondary and tertiary care (figure 1; Binns et al. 2010, Nelson et al. 2015). Public health difficulties such as reduced access to healthcare are well established (Binns et al. 2010, Bell et al. 2022); however, how the specific characteristics of islands make them unique settings for One Health research is not often considered.

In this article, we aim to examine the application of the One Health approach to islands and to highlight the potential of islands as valuable and tractable systems for understanding connections across health silos. The unique attributes of islands as geographically isolated, with relatively simple ecosystems and high degrees of endemism, have made them model systems in ecology, biogeography, and evolution throughout the history of these fields, with islands often described as tractable “natural laboratories” (e.g., Warren et al. 2015, Whittaker et al. 2017). It has already been argued in previous work that simpler, smaller, isolated insular ecosystems provide ideal laboratories to study

arboviral emergence (Tortosa et al. 2012). In the present article, we suggest that islands could represent model systems for One Health research. Moreover, given the ongoing and escalating threat of climate change, increasing One Health research and surveillance on islands is urgently needed and has global implications, with islands acting as potential sentinels as climate change progresses. We present examples from oceanic and continental islands to exemplify the diverse One Health challenges and opportunities across systems. Ultimately, our framework contributes to the growing body of knowledge on One Health and emphasizes the importance of understanding and preserving the health of interconnected ecosystems on islands and beyond.

## Islands as tractable systems for One Health research

Islands, due to their limited size and isolation, often have simplified ecological networks that we argue can be model systems for One Health research (figure 1). In particular, the relatively simple ecological networks on islands allow for the relative importance of species in the transmission of multihost neglected zoonotic disease, such as schistosomiasis to be better quantified and more effectively controlled (Webster et al. 2016, Hewitt and Willingham 2019). On Caribbean islands, for example, schistosomiasis has been controlled and eliminated on many of the islands partly as a result of a more complete understanding of reservoirs and the key intermediate hosts: freshwater snails from the genus *Biomphalaria* (and *Biomphalaria glabrata* in particular; Pointier and Jourdan 2000, Hewitt and Willingham 2019). The comparison of islands across the region has enabled researchers to identify ecological feedback loops between *B. glabrata* and competitor snails (e.g., of the Thiaridae group) that reduces *B. glabrata* abundance and, when coupled with human chemotherapy treatment, land-use change, and molluscicide, can interrupt the transmission and reduce the prevalence of schistosomiasis (Pointier and Jourdan 2000, Hewitt and Willingham 2019).

By understanding the ecological and evolutionary processes that shape island biogeography, researchers can gain insights into the factors influencing disease dynamics and develop effective strategies for disease prevention and control applicable to continental systems. Species richness and diversity on islands are strongly influenced by both island size and isolation (the theory of island biogeography; MacArthur and Wilson 1967). Stochastic processes reduce species richness on small islands, because of the higher chance of extinction in a small area and limited immigration due to geographic isolation (MacArthur and Wilson 1967). Oceans function as a strong filter on species traits limiting dispersal capability for those able to swim, fly, or raft to an island. The more isolated the island from other land masses, particularly from continents, the more limited the taxonomic lineages, resulting in high endemism and adaptive radiation of single lineages, leading to assemblages with low phylogenetic diversity (figure 1; Grant 1968). The small size of islands may also limit the number of trophic levels, whereby smaller areas of vegetation community types or simplified vegetation structures do not support the diversity and abundance of primary producers (plants) and consumers (herbivores) to support tertiary (apex predators) or even secondary (predators) consumers. Therefore, trophic networks may also be restricted (Gravel et al. 2011). Although measuring ecosystem health is challenging (Penn et al. 2024), the simplified and tractable ecosystem dynamics allow for more robust measures of ecosystem health through better understanding of ecological function (e.g., Fukami et al. 2006, Warren et al. 2015).

Another advantage of the discrete nature of islands is that they are sometimes well studied, including being comprehensively mapped, facilitating One Health research (figure 1). For example, the low species diversity of arbovirus (arthropod-borne virus) vector species allow for comprehensive entomological surveys to help uncouple local transmission from long distance spread of viruses such as Chikungunya and Dengue virus (Tortosa et al. 2012). Where affluent human societies live on islands, there are likely to be strong local scientific endeavors and institutions. Isolated volcanic island chains such as the Hawaiian Islands, which are also affluent, being part of the United States, and the Galapagos Islands (Ecuador) are well studied because their extreme isolation has given rise to unique endemic lineages of fauna derived from limited dispersal events. Populated islands offer the relatively close proximity of terrestrial (including freshwater) ecosystems with anthropogenic land uses, including agriculture and urban areas, and unambiguous examples of terrestrial-aquatic-ecosystem links (Fukami et al. 2006), including both disturbed and intact estuarine, coastal, and pelagic ecosystems. The increasing global focus on sustainability opens possibilities to compare traditional with regenerative practices in aquaculture, agriculture, and forestry and how these influence human health, as well as pathogen and antimicrobial resistance transmission. Well-studied islands, with detailed mapping of environmental layers and human impacts, can offer ideal study systems to understand the dissemination of antimicrobial resistance, zoonotic spillover, and pathogen transmission among wild, feral, and domestic animals. For example, although it is still technically challenging, high definition spatial data available in Ireland allowed for mapping of antimicrobial resistance transmission routes and sources, as well as bovine tuberculosis risk across the island (McGrath et al. 2009, Chique et al. 2019).

Another advantage of islands is the possibility of replicated study—in particular, in archipelagos, where each island functions as a discrete entity with independent ecosystems, which means replication can be achieved that is unattainable in other regions

(Fukami et al. 2006). For example, small island clusters with varying densities of feral cats and sheep farming with different degrees of isolation or movement of livestock, combined with an advanced health system, could be a tractable model to study transmission of *Toxoplasma gondii* and its impacts on human, livestock, and wildlife health, which is currently out of reach (Aguirre et al. 2019, Roberts et al. 2020). In the Caribbean, divergent rabies reservoir dynamics (caused by the rabies virus), control efforts, and outbreak histories enable unique interisland comparisons that can facilitate better understanding of globally applicable reservoir management (Seetahal et al. 2018). The unique ability to do comparative One Health research across islands is underused and can help tease apart complex One Health relationships.

## Islands as models for advancing global One Health research

Islands are well established sentinels of climate change impacts (e.g., Anson et al. 2014, Kane and Fletcher 2020). The complex links between changing climate and animal and human health have been at least partly driven by increasing One Health awareness (Muhammad-Bashir and Halimah 2022). Climate-health feedback loops are crucial for climate change adaptation; however, knowledge of these links is geographically skewed and limited, particularly on islands (Zinsstag et al. 2018, Kim et al. 2022). Low lying oceanic islands are particularly vulnerable and among the first to experience the consequences of climate change (e.g., Kane and Fletcher 2020). Unprecedented anthropogenic sea level rise, along with wave-driven flooding and salinization, poses a significant threat to the stability and habitability of some oceanic islands, particularly those located on coral atolls between 1–3 meters above sea level (Kane and Fletcher 2020). Without intervention, atoll islands will face accelerating instability, a loss of potable groundwater and agroforests, and threatened infrastructure, becoming permanently unstable before 2100 as sea levels exceed late-Holocene threshold values (Kane and Fletcher 2020). For these islands, groundwater could be permanently lost within a few decades (Kane and Fletcher 2020). The window to understand the climate–One Health nexus is brief, but the links between climate and health are still rarely quantified on islands (Kim et al. 2022).

Even for islands not located on atolls, the large coastlines relative to land size makes the issues of coastal erosion, inundation, and the increasing frequency of large storm events major challenges (Kulp and Strauss 2019, Walsh et al. 2019, Kim et al. 2022). Events such as cyclones not only threaten health infrastructure and infection control but also have One Health implications, direct and indirect (Graham et al. 2023b). Leptospirosis is a widespread zoonosis with high morbidity rates across the tropics, especially in tropical islands (Pappas et al. 2008, Biscornet et al. 2017, Guernier et al. 2018). Leptospirosis outbreaks are strongly correlated with severe weather events. In New Caledonia, during periods of flooding, both rodent abundance and their *Leptospira* infection rates increased, which, in turn, was linked to higher human exposure (Perez et al. 2011). More indirectly, the increasing frequency and intensity of storms can also affect environmental health by reducing biodiversity—for example, by increased pressure on forests through storm damage and increased risk of invasive plants (Goulding et al. 2016). For island species occupying higher altitudes, increased temperatures threaten extinction in contrast to continents migration routes are limited (Fernández-Palacios et al. 2021). To what degree these

ecosystem changes will have cascading impact on One Health challenges is an open question.

Climate change will also alter arbovirus dynamics (Mordecai et al. 2020), and islands in the tropics are recognized as arbovirus hotspots (Mavian et al. 2018). Islands in each major ocean frequently experience outbreaks of infections due to arboviruses, such as Dengue, Zika, and Chikungunya viruses. These outbreaks can have implications beyond the islands themselves, because they can facilitate the transmission of these arboviruses to adjacent continental areas, including, for example, from Caribbean islands to the United States (Mavian et al. 2018). An island in the Torres Strait, situated between Australia and Papua New Guinea, served as the first site of Japanese encephalitis virus outbreaks in Australia, with the proximity of human dwellings, domestic pigs, and environment for mosquito breeding leading to detection (Hanna et al. 1996). These outbreaks foreshadowed subsequent occurrences on continental Australia, acting as early indicators of shifting Japanese encephalitis virus dynamics (Hanna et al. 1996).

Demonstrable increases in ocean warming, acidification, and oxygen loss related to climate change are occurring across marine environments (Bindoff et al. 2024). These affect marine life at multiple levels, from molecular processes to organisms and ecosystems (Pörtner 2012) with implications for food production and human communities (Hoegh-Guldberg et al. 2019). Habitat disturbances associated with climate change (e.g., coral reef bleaching, kelp forest, and seagrass meadow contractions) are exacerbated by human activities in coastal ecosystems, such as wetland area declines and increased nutrient runoff (Bindoff et al. 2024). Consequently, food provision from oceans in many regions is already affected and predicted to become more so in the future (Hoegh-Guldberg et al. 2019). For example, it is likely that more than 50% of exploited fishes and invertebrates from the exclusive economic zones of the Pacific Island states will become locally extinct by 2100 (Asch et al. 2018).

### Terrestrial isolation and small populations

The limited terrestrial connectivity with other regions and their smaller human populations makes control of One Health threats—and infectious diseases in general—possible. Limited connectivity and discrete arrival zones such as ports and airports can help with targeted surveillance of pests, diseases, and vector species and can allow for timely and focused intervention strategies (figure 1). For example, rapid SARS-CoV-2 containment measures were more effective in island nations than in the countries with shared land boundaries because of the manageable number of physical entry points (Murphy et al. 2020). Indeed, island states were the countries that experienced the lowest global numbers of SARS-CoV-2 cases and mortalities during the first waves of the pandemic, in large part because their isolation enabled more effective closures of borders (Campbell and Connell 2021, Strøm et al. 2021). Effective border closures allowed some islands, such as the Galapagos, to successfully eradicate classical swine fever (Freire-Paspuel et al. 2020). Advancing One Health research and increasing surveillance capacity in this area represents good value for money as control is possible and easier to achieve than in similar continental regions.

Once an exotic pathogen arrives on an island, however, the trait of geographic isolation may be detrimental to island populations due to higher degrees of immune naivety (figure 1). For example, the accidental introduction of avian malaria, *Plasmodium relictum*, to the islands of Hawaii has led to catastrophic declines in endemic bird species (e.g., Atkinson et al. 1995, Wood-

worth et al. 2005, Neddermeyer et al. 2023). The immunological naivety of Hawaiian birds to the mosquito-borne pathogen is one likely mechanism underlying the declines (Atkinson et al. 1995). Similar patterns have been found in endemic rodent species on Christmas Island with the introduction of a pathogenic trypanosome (Pickering and Norris 1996). This naivety to disease of island species makes the introduction of disease an important extinction threat across taxa (Wikelski et al. 2004).

Increased One Health capacity building and research efforts on islands will benefit the human, animal, and plant populations by mitigating the impacts of climate change, population naivety to disease and provide important global lessons for climate change adaptation. Islands are already providing insights into the socio- and biophysical challenges of at least 1.5 degree Celsius increase poses for humans (Albert et al. 2018), and increasing One Health research on islands promises to help quantify health–climate links that are globally relevant.

### Testing the dilution effect

We argue that simplified and discrete ecological networks on islands provide unique opportunities to explore how species diversity shapes disease outbreaks across the One Health interface via the dilution effect. The dilution effect occurs when adding reservoir-incompetent host species to a community (e.g., by introductions) reduces the transmission of enzootic pathogens maintained by competent reservoir hosts (e.g., Norman et al. 1999, Ostfeld and Keesing 2000). This effect reduces pathogen abundance, decreases persistence likelihood, and has significant implications for public health and land management decisions regarding biodiversity (Keesing et al. 2006). Conversely, disease could be amplified (e.g., increased prevalence) in systems such as islands, where species diversity is low and contact between more taxonomically closely related species is high (Keesing et al. 2006). This amplification effect may underlie the increased prevalence of leptospirosis on Pacific islands and the Seychelles (Derne et al. 2011, Biscornet et al. 2017). Furthermore, the species that have colonized islands recently or are introduced by humans tend to be good dispersers and fast-lived species (i.e., species with rapid growth and short life spans) that may be more competent hosts for some pathogens (e.g., Johnson et al. 2012, Dietrich et al. 2014, Albery and Becker 2021). In Madagascar, it has been reported that endemic small mammals carry *Leptospira* species different from those in introduced rats, suggesting that endemic versus introduced mammal species harbor different roles in the local epidemiology of leptospirosis (Dietrich et al. 2014). Experimental infections later suggested that endemic mammals show a strong host specificity to their *Leptospira* (Cordonin et al. 2020) and that *Leptospira* strains shed by endemic mammals in specific insular ecosystems (*Leptospira mayottensis* isolated from a tenrec in Mayotte; *Leptospira borgpetersenii* isolated from a bat in Madagascar) are less pathogenic than the ubiquitous *Leptospira interrogans* rat-borne isolate (isolated in Reunion Island, Cordonin et al. 2019).

Disease dynamics and the risk of spillover could be altered by the island animal communities often consisting of phylogenetically related species. The high degrees of species endemism often found on islands may protect island faunas from disease; however, reduced species phylogenetic diversity on islands may increase the chances of spillover between species (Fountain-Jones et al. 2018). Briefly, this is because closely related species tend to be more biologically similar and share similar immune

**Box 1. Migrating predators and the case of influenza.**

Marine predators, including pinnipeds (seals) and marine birds, are potential vectors of disease in the marine environment. Breeding marine birds and mammals on islands tend to form dense aggregations typically covered in excretions that provide ideal outbreak conditions (Vanstreels et al. 2023). Following the breeding months, millions of marine birds and mammals set out on long-distance seasonal migrations (Hindell et al. 2020), crossing hemispheres and participating in food webs on different continents. As an example, short-tailed shearwaters (*Ardeana tenuirostris*) are a pelagic seabird that breed on the islands of Tasmania, Australia, then fly to the Northern Hemisphere to spend the boreal summer in Alaska, Russia, and the Bering Sea (Carey et al. 2014). The species is consumed by humans in Tasmania (Lavers and Bond 2013). Although the role of migratory marine birds as disease vectors is somewhat understudied, there is evidence for transport of various pathogens including *Borrelia* (Comstedt et al. 2011), *Campylobacter* and *Salmonella* (Moré et al. 2017).

Since October 2021, high-pathogenicity avian influenza (HPAI) H5N1 lineage 2.3.4.4b has swept across the Northern Hemisphere, the Americas, and Africa, resulting in the destruction of more than half a billion poultry and mass mortalities in wild birds and marine mammals (Gamarra-Toledo et al. 2023, Klaassen and Wille 2023, Leguia et al. 2023). At least 356 species of birds experienced mortality (Klaassen and Wille 2023), island populations of wildlife have been decimated (Camphuysen and Gear 2022, Knief et al. 2024) and at least seven humans infected (three fatally in 2023; Bruno et al. 2023). As of September 2024, the only continent free of this panzootic is Australia. HPAI is a clear One Health challenge. Although low-pathogenicity avian influenza is maintained in wildlife species, the emergence of HPAI has been typically linked directly with poultry production (Gilbert et al. 2017). The HPAI H5N1 2.3.4.4b lineage has altered this pattern and the toll of this panzootic on wildlife and ecosystems is enormous and it may take years for us to understand its long-term effects. Likewise, the economic cost is yet to be tallied, but the last major outbreak of HPAI in the United States (2014–2016) led to the deaths of 50 million domestic birds, at a cost of at least US\$1 billion (Seeger et al. 2021). HPAI H5N1 2.3.4.4b has been unprecedented in its rapid spread, carried across oceans, between continents, and onto islands, largely by migratory birds (Caliendo et al. 2022, Lv et al. 2022).

profiles and are therefore susceptible to infectious disease (Longdon et al. 2011). Outbreaks of high-pathogenicity avian influenza are more likely in wild bird communities with low phylogenetic diversity than in more diverse communities (boxes 1–3; Huang et al. 2019). Higher infectious disease burdens in wildlife have clear implications for human health with, for example, areas of low-phylogenetic diversity of rodents in the United States recording more cases of Lyme disease in humans than in areas with higher diversity (Wang et al. 2023). Whether this is true in island ecosystems remains an open question.

**Aquatic connectivity**

Although islands are physically isolated, they are connected by the ocean. Ocean connectivity is greater than terrestrial, at least partly because of the physical differences between water and air (McCallum et al. 2003). This connectivity is essential for the life cycles of some marine animals, but it also promotes transmission of pathogens, including those affecting both highly mobile and sessile hosts (McCallum et al. 2003). For example, in 1995 herpes virus spread through mobile pilchard populations in Australia and New Zealand at up to 45 kilometers per day and 11,000 kilometers per year (Jones et al. 1997, Murray et al. 2001) whereas *Neoparamoeba invadens*, an amoeba pathogenic to sea urchins, had a maximum rate of spread of 986 kilometers per year (Miller and Colodey 1983). Marine currents and paratenic hosts are also implicated in the spread of *Toxoplasma gondii*, a parasite with a complex cycle involving cats and various mammals or birds, because antibodies against *T. gondii* in over 1000 pelagic seabirds were detected in seabirds from cat-colonized but also cat-free islands in the Western Indian Ocean (Pouille et al. 2021). Inert materials such as floating plastic debris provide the potential for connectivity between islands and have been proposed as a potential vector for pathogenic bacteria (Bowley et al. 2021). Although a variety of human and animal pathogens have been identified as part of the bacterial communities living on microplastics, their pathogenicity potential or extent to which human and animal

pathogen transmission occurs via this route is unknown (Bowley et al. 2021, Beloe et al. 2022).

**Islanders interact with aquatic ecosystems**

Island inhabitants often have close connections to their aquatic environments, which occupy a prominent role in cultural and recreational activities, as well as practical roles in transport and food provision. This close link between island communities and their aquatic environments provides an excellent setting for the understanding of ecosystem changes in response to these multiple stressors. Several of the Pacific Islands have relatively large exclusive economic zones. For example, the Pacific Island country of Nauru controls an exclusive economic zone that is 15,000 times larger than its total landmass. Although little research has been devoted to links between human and animal health and the health of the aquatic environment, a One Health approach is equally valid in this setting. Pollution, plastics (including microplastics), overfishing, aquatic pathogens, and climate change are threats to environmental health that are relevant in a One Health context (Norman et al. 2023).

Two examples of this are *Vibrio* bacteria and harmful algae. *Vibrio* spp. are ubiquitous in aquatic environments and can be both commensal organisms in marine biota (Egerton et al. 2018) and common pathogens of finfish, shellfish, and shrimp capable of causing large scale mortalities in aquaculture (Worden et al. 2022, Cowan et al. 2023). Increases in the environmental levels of *Vibrio* related to climate change are well noted (e.g., Baker-Austin et al. 2013). At the same time, the incidence of human vibriosis is rising worldwide (WHO 2020, Trinanes and Martinez-Urtaza 2021). *Vibrio vulnificus* causes 95% of seafood related mortalities in the United States (Oliver 2015, Heng et al. 2017), and *Vibrio parahaemolyticus* is a leading cause of seafood related foodborne illness in the many areas of the world (Baker-Austin et al. 2018, WHO 2020). This is particularly important for those island communities that rely more on seafood as a source of protein—for example, the communities from Pacific islands (O’Meara et al. 2023).

## Box 2. Fiji: A model of One Health research in the Pacific.

Fiji, an archipelago nation of over 300 oceanic islands in the South Pacific, faces a myriad of One Health threats due to its geographic and environmental characteristics. Situated in a tropical climate zone, Fiji's diverse ecosystems support a rich marine biodiversity. Fiji considers itself to be a "large ocean state" as its exclusive economic zone is 70 times larger than its landmass and includes more than 10,000 km<sup>2</sup> of coral reefs. This results in a high level of biodiversity with more than 12,000 species of fish, 800 species of mollusks and 350 species of hard coral. Comparatively, the terrestrial fauna is much less diverse than continental locations at the same latitude with 76 vertebrate species (including five mammal species; Pernetta and Watling 1978). The Republic of Fiji, with a Human Development Index (HDI) of .743, ranks among the largest economies in the South Pacific. Approximately 75% of the Fijian population lives in coastal zones on Viti Levu Island (Swail et al. 2019).

### Terrestrial ecosystems and One Health threats in Fiji

Leptospirosis is a widespread zoonosis in the Pacific Islands, with some epidemiological heterogeneity within and between islands that needs to be better understood (Guernier et al. 2018). In Fiji for example, human leptospirosis presents a significant health concern, attributed to its specificities, including a tropical climate and frequent heavy rainfall, which provide ideal conditions for the survival and transmission of *Leptospira* bacteria (e.g., Lau et al. 2016, Reid et al. 2017, Naing et al. 2019). The disease is notably prevalent in rural and periurban areas of Fiji, where agricultural activities are common, and individuals have frequent contact with contaminated water sources (Lau et al. 2016). Community-level exposure to livestock, especially pigs and cows, also seems to be a strong predictor of the risk of leptospirosis infection (Lau et al. 2017). Flooding events, exacerbated by climate change, further propagate the spread of pathogenic *Leptospira* through contaminated water and soil, heightening the risk of infection for both humans and animals (e.g., Lau et al. 2010). Socio-economics and poor living conditions have also been linked to higher risk of infection (Lau et al. 2016). Limited access to healthcare services in remote regions of Fiji exacerbates the impact of leptospirosis, highlighting the urgent need for targeted public health interventions to mitigate its transmission (Lau et al. 2016). Mosquito-borne viruses such as Dengue, Zika, and Chikungunya viruses pose ongoing threats to public health, particularly in urban areas where population density is high (Roth et al. 2014). Antibiotic resistance is also a growing concern, with antimicrobial surveillance programs providing valuable insights into the prevalence and distribution of resistant bacteria (World Health Organization 2014). Remote areas of the Fiji Islands may experience lower levels of antimicrobial resistance compared with urban centres, highlighting the importance of understanding regional variations in resistance patterns (Robbins et al. 2024).

### Aquatic ecosystems and One Health threats in Fiji

Many islanders around the world rely heavily on the health of their marine environment, especially its reefs, which are vital for traditional ways of life, artisanal fishing as well as being the dominant source of protein in some communities. This is the case in Fiji. But poisoning due to consumption of fish containing natural toxins has significantly increased in Fiji and could be associated with marine heatwaves (Holbrook et al. 2022). Thirty-four species of reef fish were identified as potentially toxic mostly because of the presence of tetrodotoxins, palytoxin, or ciguatoxin, particularly under warmer conditions (Lako et al. 2023). Also, the ocean is a reservoir of antibiotic resistant genes (Hatosy and Martiny 2015), and around Fiji, pharmaceutical residues detrimental to marine life, including antibiotics, have been detected in seawater samples even in coastal areas with low population (Dehm et al. 2021). Currently, there is a lack of information on ocean antimicrobial resistance from Pacific Island countries (Loftus et al. 2020, Xu et al. 2023). Similarly, there is little information on infection of fish from Fiji by zoonotic parasites, making risk assessment for zoonosis due to seafood consumption difficult.

Primary production from phytoplankton is the basis of food chains in aquatic systems. Significant interest has been focused on those algae able to produce marine biotoxins (Hallegraeff et al. 2021b), a range of lipophilic and hydrophilic metabolites that potentially play a role in avoiding zooplankton grazing pressure (Turner 2014). These biotoxins accumulate in the food chain—notably, amnesic, diarrhetic, or paralytic shellfish toxins in bivalve shellfish, carnivorous mollusks, and crustacea (e.g., Hallegraeff et al. 2021b) or ciguatoxins in finfish (Chinain et al. 2020). Depending on the toxin group, a range of human illnesses can result (FAO 2004). However, marine biotoxins can also cause mass mortality events of marine animals across multiple trophic levels (Starr et al. 2017, Hallegraeff et al. 2021a, Rolton et al. 2022) or can affect the neurological, physiological, and behavioral responses of bivalves (Kvitek et al. 1991, Bricelj et al. 2011) and marine invertebrates, notably affecting metabolism, immune responses, fecundity, and juvenile survival and growth (Haberkorn et al. 2010, Goic et al. 2013, Navarro et al. 2016) and, therefore, also ecosystem health.

Growing aquaculture production is seen as an important component in world food security (Azra et al. 2021, Garlock et al. 2022), and small island developing states are increasingly looking to aquaculture for economic development (FAO 2017). More broadly, marine environmental health is essential to the health of coastal communities relying on the ocean for their food, shelter, livelihoods, and other resources (Fleming et al. 2019). Mental health and well-being has been associated with closeness to coastal areas as a result of lower stress, physically active lifestyles and social interactions (Garrett et al. 2019, Britton et al. 2020, Nash et al. 2022). At the same time, human activities can adversely affect the marine environment and, as a result, can affect human health. This illustrates the interdependence of human and environmental health and the significance of a One Health approach for investigating environmental, animal, and human health issues.

### Box 3. One Health on the continental island of Tasmania.

A contrasting system to Fiji, but one that also offers exceptional opportunity to apply a One Health approach is the temperate continental island of Tasmania (situated 42 degrees south, 68,401 square kilometers), part of and situated south of the world's smallest continent, Australia. Tasmania has the advantage of being a high HDI country that is exceptionally well studied and mapped, including well-studied ecological networks of terrestrial mammal fauna (Cunningham et al. 2018). It also has threats deriving from the human activity of all major land uses (agriculture, forestry, mining, fishing and aquaculture) and its high level of endemism in the biota. Tasmania's biota, both endemics and representatives of most taxa on the adjacent mainland, reflects both its significant isolation as well as frequent connection with the supercontinent of Sahul during the glacial maxima and its proximity (240 kilometers).

Tasmania is climatically and environmentally diverse, and has both a high proportion of intact landscapes (approximately 50% reserves) concentrated in the western half of the island and the oldest and most fragmented agricultural landscape in Australia (Midlands agricultural region 87% cleared; Davidson et al. 2021). High abundance of rabbits and rodents, as well as the concomitant decline of the apex terrestrial predator and scavenger, the Tasmanian devil (*Sarcophilus harrisii*), have contributed to high densities of feral cats (Hollings et al. 2014, Cunningham et al. 2018, Hamer et al. 2021). Those herbivorous preys also feed native carnivores (Andersen et al. 2017, Hamer et al. 2021). Such close contact between wildlife, invasive and domestic species could cause for pathogen spillover and spillback. As an example of disease cascade, high cat densities in areas of Tasmanian devil decline have been associated with high prevalence of *Toxoplasma gondii* in the native herbivore rufous-bellied pademelon (*Thylogale billardierii*; Hollings et al. 2014).

A warming climate is increasing spillover of several viruses in this temperate island Macropods and as reservoir hosts for the Ross River virus, Tasmania's most significant mosquito-borne virus (Harley et al. 2001, Koolhof and Carver 2017). Ross River virus is endemic throughout Australia, with occasional epidemics occurring in the South Pacific, leading to manifestations of fatigue and polyarthritides (Harley et al. 2001). Although cases are presently rare and confined to the east coast of Tasmania, rising temperatures are expected to facilitate an increase in the transmission of Ross River virus by increasing mosquito survival (Shocket et al. 2018). Another mosquito-borne virus, the Japanese encephalitis virus, is currently undetected on the island but is at its doorstep in south-eastern Australia (van den Hurk et al. 2022). Similarly to Ross River virus, climate change and increased temperature are likely to favor the emergence of the Japanese encephalitis virus in new territories due to increased mosquito survival and changing wild bird migrations (Brinkhoff 2023).

*Salmonella* serotype Mississippi infections are very common in Tasmania, representing 80% of Australian notifications (Ashbolt and Kirk 2006). Infection sources include Tasmanian wildlife such as skinks, eastern quolls (*Dasyurus viverrinus*) and kangaroos (*Macropus giganteus tasmaniensis*), with 50% of 120 eastern quolls sampled infected with *Salmonella*, of which 97% was Mississippi (Ball 1991). The Tasmanian reservoir of *Salmonella* Mississippi appears to be the native animal population, which contaminates water supplies leading to sporadic human infections: *Salmonella* was detected in 1.6% of 500 reticulated drinking water sources and 8.2% of 250 natural fresh water sources of which 53% were Mississippi (Ashbolt and Kirk 2006).

As with most places on the globe, antimicrobial resistance is an important issue for Tasmania and surveillance is reasonably comprehensive given the size of the island (Australian Commission on Safety and Quality in Health Care 2014). Tasmania has the lowest proportion of resistance in priority antimicrobial resistance pathogens in Australia (Australian Commission on Safety and Quality in Health Care 2023). This includes lowest reported rates of methicillin-resistant *Staphylococcus aureus*, ceftriaxone-, gentamicin-, and ciprofloxacin-resistant *Escherichia coli* from bloodstream infections, the lowest state notifications of critical antibiotic resistances reported to the CARAlert program, such as carbapenem-resistant Enterobacterales, *Pseudomonas aeruginosa* and *Acinetobacter baumannii*, and an absence of *Candida auris* and ceftriaxone-resistant *Salmonella* infections. These findings are also mirrored in community surveillance; for example, urinary *Escherichia coli* had much lower levels of antimicrobial resistance compared with mainland Australia (Meumann et al. 2015). If the lower levels of antimicrobial resistance either a product or a function of relative isolation compared with continental Australia or mediated by environment and climate (e.g., Li et al. 2023) is unknown. Reduced resistance, however, may facilitate more tractable analyses of antimicrobial resistance spread from environmental and animal sources (Bengtsson-Palme et al. 2023)

#### Aquatic ecosystems and One Health threats in Tasmania

Globally, due to climate change, the marine environment is undergoing measurable changes to key physical parameters such as temperature, salinity, and acidity, with an increase in the frequency of marine heat waves and storm events (Whetten et al. 2015). In Tasmania, changes are occurring on the ecological level that are altering marine ecology (e.g., changing species distributions; Pecl et al. 2014), including invasions of introduced species such as the long-spined sea urchin *Centrostephanus rodgersi* (Johnson et al. 2011) or the loss of giant kelp habitat (Layton et al. 2020 et al. 2020). Such ecological changes can be associated to the emergence of new health threats. During the 2016 marine heat wave, the oyster herpes virus (ostreid herpesvirus 1) was detected for the first time in Tasmania, causing over \$12 million in industry losses through oyster mortalities, and the first human health outbreak of vibriosis associated with consumption of Tasmanian oysters was recorded (Harlock et al. 2022). Another example is the impact of recurrent toxic algal blooms on Tasmania east coast since 2012, causing fisheries closures across multiple species (McLeod et al. 2017, Seger et al. 2020) and several human hospitalizations (Edwards et al. 2018).



## Islands as One Health sentinels: Surveillance opportunities

For a genuine One Health model to succeed in any system, having a surveillance system that spans humans, domestic and wild animals, and the environment is essential. Although multisector coordination can be logistically simpler on islands, as with most One Health approaches, environmental surveillance is the weakest component or is missing altogether (e.g., Iossa and White 2018). Such surveillance is necessary for understanding patterns of antimicrobial resistance in environmental reservoirs of resistance (Iossa and White 2018, Chique et al. 2019). Notably, water bodies can facilitate the spread of antimicrobial resistance (e.g., Singh et al. 2022); therefore, water monitoring is important for understanding antimicrobial resistance dynamics on islands (figure 1). Bacterial genera and their resistance genes are regularly shared across biomes from air, soil, and water, so monitoring across systems is crucial but is rarely achieved (BIOHAZ et al. 2021, Luiken et al. 2022). Emerging metagenomic frameworks using Oxford Nanopore Technologies' sequencing, such as ARGpore2 (Wu et al. 2022), offer exciting and cost-effective possibilities for surveillance of water, soil, and dust samples (Eltokhy et al. 2021, Li et al. 2021). Moreover, metagenomic surveillance spanning terrestrial and marine systems promises a better understanding of the complex interactions that shape ecosystems (Clarke et al. 2020). As small, discrete units, islands offer an ideal living laboratory to apply a metagenomic surveillance regime that represents key ecosystems, animal species, and human population centers. Existing projects such as the World Network of Island and Coastal Biosphere Reserves (<https://core.unesco.org/en/project/526GLO2012>) promise to integrate strategies for ecosystem restoration that will also have One Health relevance. Integrated insular surveillance systems will not only lead to better management of health threats on islands but will also have implications and benefits for larger continental areas.

The opportunities and importance of One Health on islands underscore the need for geographically tailored strategies. Islands, characterized by diverse connectivity and development statuses, can serve as tractable systems for understanding disease dynamics because of their simplified ecological networks and well-studied ecosystems. Reduced connectivity (in most circumstances) and smaller populations enhance the manageability of targeted surveillance and intervention strategies, and this can lead to successful containment measures. However, the effects of isolation also shape species diversity and evolutionary relationships, contributing to the intricate interplay between island ecology and disease dynamics. Connectivity between anthropogenic impacts on the land to the sea is important for islands, given their relatively larger exclusive economic zones compared with their total land mass and greater reliance on natural resource harvest from the sea for human sustenance. A holistic approach is needed to address the interconnectedness of human, animal, and environmental health because of the close relationship between island communities.

### Author contributions

Nicholas M Fountain-Jones: conceptualization, figure creation, writing—original draft, writing—review and editing; Kate S Hutson: figure creation, writing—original draft, writing—review and editing; Menna Jones: writing—original draft, writing—review and editing; Barbara F Nowak: writing—original draft, writing—review and editing; Alison Turnbull: writing—original draft, writing—review and editing; Jane Younger: writing—

original draft, writing—review and editing; Malgorzata O'Reilly: writing—original draft, writing—review and editing; Emma Watkins: writing—original draft, writing—review and editing; Vanina Guernier-Cambert, Louise Cooley: writing—original draft, writing—review and editing; Rodrigo Hamede: conceptualization, writing—review and editing.

### Funding

FJ was funded by the Australian Research Council Discovery Grant (DP230100162). KH was funded by the New Zealand Ministry of Business, Innovation and Employment, under the programme Emerging Aquatic Diseases: a novel diagnostic pipeline and management framework (CAWX2207).

### References cited

- Adisasmito WB, et al. 2022. One Health: A new definition for a sustainable and healthy future. *PLOS Pathogens* 18: e1010537. <https://doi.org/10.1371/journal.ppat.1010537>
- Aguirre AA, et al. 2019. The One Health approach to toxoplasmosis: Epidemiology, control, and prevention strategies. *Ecohealth* 16: 378–390. <https://doi.org/10.1007/s10393-019-01405-7>
- Albert S, Bronen R, Tooler N, Leon J, Yee D, Ash J, Boseto D, Grinham A. 2018. Heading for the hills: Climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5°C future. *Regional Environmental Change* 18: 2261–2272. <https://doi.org/10.1007/s10113-017-1256-8>
- Albery GF, Becker DJ. 2021. Fast-lived hosts and zoonotic risk. *Trends in Parasitology* 37: 117–129. <https://doi.org/10.1016/j.pt.2020.10.012>
- Andersen GE, Johnson CN, Barmuta LA, Jones ME. 2017. Dietary partitioning of Australia's two marsupial hypercarnivores, the Tasmanian devil and the spotted-tailed quoll, across their shared distributional range. *PLOS ONE* 12: e0188529. <https://doi.org/10.1371/journal.pone.0188529>
- Ansorge JJ, Durgadoo JV, Treasure AM. 2014. Sentinels to climate change. The need for monitoring at South Africa's subantarctic laboratory. *South African Journal of Science* 110: 1–4. <https://doi.org/10.1590/sajs.2014/a0044>
- Asch RG, Cheung WWL, Reygondeau G. 2018. Future marine ecosystem drivers, biodiversity, and fisheries maximum catch potential in Pacific Island countries and territories under climate change. *Marine Policy* 88: 285–294. <https://doi.org/10.1016/j.marpol.2017.08.015>
- Ashbolt R, Kirk MD. 2006. Salmonella Mississippi infections in Tasmania: The role of native Australian animals and untreated drinking water. *Epidemiology and Infection* 134: 1257–1265. <https://doi.org/10.1017/S0950268806006224>
- Atkinson CT, Woods KL, Dusek RJ, Sileo LS, Iko WM. 1995. Wildlife disease and conservation in Hawaii: Pathogenicity of avian malaria (*Plasmodium relictum*) in experimentally infected liwi (*Vestiaria coccinea*). *Parasitology* 111: S59–S69. <https://doi.org/10.1017/S003118200007582X>
- Australian Commission on Safety and Quality in Health Care. 2014. Preliminary Report on Antimicrobial Use and Resistance in Australia. Australian Commission on Safety and Quality in Health Care. <https://www.safetyandquality.gov.au/publications-and-resources/resource-library/preliminary-report-antimicrobial-use-and-resistance-australia>
- Australian Commission on Safety and Quality in Health Care. 2023. AURA 2023: Fifth Australian Report on Antimicrobial Use and Resistance in Human Health—Report. Australian Commission

- on Safety and Quality in Health Care. [www.safetyandquality.gov.au/publications-and-resources/resource-library/aura-2023-fifth-australian-report-antimicrobial-use-and-resistance-human-health-report](http://www.safetyandquality.gov.au/publications-and-resources/resource-library/aura-2023-fifth-australian-report-antimicrobial-use-and-resistance-human-health-report)
- Azra MN, Okomoda VT, Tabatabaei M, Hassan M, Ikhwanuddin M. 2021. The contributions of shellfish aquaculture to global food security: Assessing its characteristics from a future food perspective. *Frontiers in Marine Science* 8: 654897. <https://doi.org/10.3389/fmars.2021.654897>
- Baker-Austin C, Trinanes JA, Taylor NGH, Hartnell R, Siitonen A, Martinez-Urtaza J. 2013. Emerging *Vibrio* risk at high latitudes in response to ocean warming. *Nature Climate Change* 3: 73–77. <https://doi.org/10.1038/nclimate1628>
- Baker-Austin C, Oliver JD, Alam M, Ali A, Waldor MK, Qadri F, Martinez-Urtaza J. 2018. *Vibrio* spp. infections. *Nature Reviews Disease Primers* 4: 1–19. <https://doi.org/10.1038/s41572-018-0005-8>
- Ball A. 1991. *The Epidemiology of Salmonella Serovars in Tasmania*. Master's thesis, University of Tasmania, Hobart.
- Bell L, Gemert Cv, Merilles OE, Cash HL, Stoové M, Hellard M. 2022. The impact of COVID-19 on public health systems in the Pacific Island countries and Territories. *Lancet Regional Health—Western Pacific* 25: 100498. <https://doi.org/10.1016/j.lanwpc.2022.100498>
- Beloe CJ, Browne MA, Johnston EL. 2022. Plastic debris as a vector for bacterial disease: An interdisciplinary systematic review. *Environmental Science and Technology* 56: 2950–2958. <https://doi.org/10.1021/acs.est.1c05405>
- Bengtsson-Palme J, et al. 2023. Towards monitoring of antimicrobial resistance in the environment: For what reasons, how to implement it, and what are the data needs? *Environment International* 178: 108089. <https://doi.org/10.1016/j.envint.2023.108089>
- Bindoff NL, Cheung WWL, Kairo JG. 2024. Changing ocean, marine ecosystems, and dependent communities. Pages 447–587 in Pörtner H-O, et al., eds. Special Report on the Ocean and Cryosphere in a Changing Climate. Intergovernmental Panel on Climate Change. [www.ipcc.ch/srocc/chapter/chapter-5](http://www.ipcc.ch/srocc/chapter/chapter-5)
- Binns C, Hokama T, Low WY. 2010. Island health: Hope and challenges for public health. *Asia-Pacific Academic Consortium for Public Health* 22: 19–24. <https://doi.org/10.1177/1010539509357782>
- Biscornet L, et al. 2017. Human leptospirosis in Seychelles: A prospective study confirms the heavy burden of the disease but suggests that rats are not the main reservoir. *PLOS Neglected Tropical Diseases* 11: e0005831. <https://doi.org/10.1371/journal.pntd.0005831>
- Boissier J, et al. 2016. Outbreak of urogenital schistosomiasis in Corsica (France): An epidemiological case study. *Lancet Infectious Diseases* 16: 971–979. [https://doi.org/10.1016/S1473-3099\(16\)00175-4](https://doi.org/10.1016/S1473-3099(16)00175-4)
- Bowley J, Baker-Austin C, Porter A, Hartnell R, Lewis C. 2021. Oceanic hitchhikers: Assessing pathogen risks from marine microplastic. *Trends in Microbiology* 29: 107–116. <https://doi.org/10.1016/j.tim.2020.06.011>
- Bricej V, Ford S, Lambert C, Barbou A, Paillard C. 2011. Effects of toxic *Alexandrium tamarense* on behavior, hemocyte responses, and development of brown ring disease in Manila clams. *Marine Ecological Progress Series* 430: 35–48. <https://doi.org/10.3354/meps09111>
- Brinkhoff MN. 2023. Comment on van den Hurk et al.: The emergence of Japanese encephalitis virus in Australia in 2022: Existing knowledge of Mosquito vectors. *Viruses* 15: 270. <https://doi.org/10.3390/v15020270>
- Britton E, Kindermann G, Domegan C, Carlin C. 2020. Blue care: A systematic review of blue space interventions for health and well-being. *Health Promotion International* 35: 50–69. <https://doi.org/10.1093/heapro/day103>
- Bruno A, Alfaro-Núñez A, de Mora D, Armas R, Olmedo M, Garcés J, Garcia-Bereguain MA. 2023. First case of human infection with highly pathogenic H5 avian influenza A virus in South America: A new zoonotic pandemic threat for 2023? *Journal of Travel Medicine* 30: taad032. <https://doi.org/10.1093/jtm/taad032>
- Caliendo V, et al. 2022. Transatlantic spread of highly pathogenic avian influenza H5N1 by wild birds from Europe to North America in 2021. *Scientific Reports* 12: 11729. <https://doi.org/10.1038/s41598-022-13447-z>
- Campbell Y, Connell J. 2021. COVID-19 and small island states. Pages 1–39 in Campbell Y Connell J, eds. *COVID in the Islands: A Comparative Perspective on the Caribbean and the Pacific*. Springer Nature.
- Camphuysen C, Gear S. 2022. Great Skuas and Northern Gannets on Foula, Summer 2022: An Unprecedented, H5N1 Related Massacre. NIOZ. doi:10.25850/nioz/7b.b.gd
- Carey MJ, Phillips RA, Silk JRD, Shaffer SA. 2014. Trans-equatorial migration of short-tailed shearwaters revealed by geolocators. *Emu—Austral Ornithology* 114: 352–359. <https://doi.org/10.1071/MU13115>
- Chinain M, et al. 2020. Evidence for the range expansion of ciguatera in French Polynesia: A revisit of the 2009 mass-poisoning outbreak in Rapa Island (Australes Archipelago). *Toxins* 12: 759. <https://doi.org/10.3390/toxins12120759>
- Chique C, Cullinan J, Hooban B, Morris D. 2019. Mapping and analysing potential sources and transmission routes of antimicrobial resistant organisms in the environment using geographic information systems: An exploratory study. *Antibiotics* 8: 16. <https://doi.org/10.3390/antibiotics8010016>
- Clarke LJ, et al. 2020. Mainstreaming microbes across biomes. *BioScience* 70: 589–596. <https://doi.org/10.1093/biosci/biaa057>
- Comstedt P, Jakobsson T, Bergström S. 2011. Global ecology and epidemiology of *Borrelia garinii* spirochetes. *Infection Ecology and Epidemiology* 1: 9545. <https://doi.org/10.3402/iee.v1i0.9545>
- Cordonin C, Turpin M, Bascands J-L, Dellagi K, Mavingui P, Tortosa P, Roche M. 2019. Three *Leptospira* strains from Western Indian Ocean wildlife show highly distinct virulence phenotypes through hamster experimental infection. *Frontiers in Microbiology* 10: 382. <https://doi.org/10.3389/fmicb.2019.00382>
- Cordonin C, Turpin M, Bringart M, Bascands J-L, Flores O, Dellagi K, Mavingui P, Roche M, Tortosa P. 2020. Pathogenic *Leptospira* and their animal reservoirs: Testing host specificity through experimental infection. *Scientific Reports* 10: 7239. <https://doi.org/10.1038/s41598-020-64172-4>
- Cowan MW, Pearce CM, Finston T, Meyer GR, Marshall R, Evans W, Sutherland TF, de la Bastide PY. 2023. Role of the *Vibrio* community, reproductive effort, and environmental parameters in intertidal Pacific oyster summer mortality in British Columbia, Canada. *Aquaculture* 565: 739094. <https://doi.org/10.1016/j.aquaculture.2022.739094>
- Cunningham CX, Johnson CN, Barmuta LA, Hollings T, Woehler EJ, Jones ME. 2018. Top carnivore decline has cascading effects on scavengers and carrion persistence. *Proceedings of the Royal Society B* 285: 20181582. <https://doi.org/10.1098/rspb.2018.1582>
- Davidson N, Bailey T, Burgess S. 2021. Restoring the Midlands of Tasmania: An introduction. *Ecological Management and Restoration* 22: 3–10.
- Davis J. 2016. *Industry Response to Pacific Oyster Mortality Syndrome (POMS)*. Fisheries Research and Development Corporation.
- Dehm J, Singh S, Ferreira M, Piovano S, Fick J. 2021. Screening of pharmaceuticals in coastal waters of the southern coast of Viti Levu in Fiji, South Pacific. *Chemosphere* 276: 130161. <https://doi.org/10.1016/j.chemosphere.2021.130161>

- Derne BT, Fearnley EJ, Lau CL, Paynter S, Weinstein P. 2011. Biodiversity and leptospirosis risk: A case of pathogen regulation? *Medical Hypotheses* 77: 339–344. <https://doi.org/10.1016/j.mehy.2011.05.009>
- Destoumieux-Garzón D, et al. 2018. The One Health concept: 10 years old and a long road ahead. *Frontiers Veterinary Science* 5: 14. <https://doi.org/10.3389/fvets.2018.00014>
- Dietrich M, Wilkinson DA, Soarimalala V, Goodman SM, Dellagi K, Tortosa P. 2014. Diversification of an emerging pathogen in a biodiversity hotspot: *Leptospira* in endemic small mammals of Madagascar. *Molecular Ecology* 23: 2783–2796. <https://doi.org/10.1111/mec.12777>
- Edwards LJ, Wilson K, Veitch MG. 2018. An outbreak of paralytic shellfish poisoning in Tasmania. *Communicable Disease Intelligence* 42: 4.
- Egerton S, Culloty S, Whooley J, Stanton C, Ross RP. 2018. The gut microbiota of marine fish. *Frontiers in Microbiology* 9. <https://doi.org/10.3389/fmicb.2018.00873>
- Eltokhy MA, Saad BT, Eltayeb WN, El-Ansary MR, Aboshanab KM, Ashour MSE. 2021. A metagenomic nanopore sequence analysis combined with conventional screening and spectroscopic methods for deciphering the antimicrobial metabolites produced by *Alcaligenes faecalis* soil isolate MZ921504. *Antibiotics* 10: 1382. <https://doi.org/10.3390/antibiotics10111382>
- Essack SY. 2018. Environment: The neglected component of the one Health triad. *Lancet Planetary Health* 2: e238–e239. [https://doi.org/10.1016/S2542-5196\(18\)30124-4](https://doi.org/10.1016/S2542-5196(18)30124-4)
- [FAO] Food and Agriculture Organization of the United Nations. 2004. *Marine Biotoxins*. FAO. Food and Nutrition Paper no. 80. [www.fao.org/3/y5486e/y5486e00.htm](http://www.fao.org/3/y5486e/y5486e00.htm)
- [FAO] Food and Agriculture Organization of the United Nations. 2017. *Blue Growth Initiative: Partnering with Countries to Achieve the Sustainable Development Goals*. FAO.
- Fernández-Palacios JM, et al. 2021. Scientists' warning: The outstanding biodiversity of islands is in peril. *Global Ecology and Conservation* 31: e01847. <https://doi.org/10.1016/j.gecco.2021.e01847>
- Fleming LE, Maycock B, White MP, Depledge MH. 2019. Fostering human health through ocean sustainability in the 21st century. *People and Nature* 1: 276–283. <https://doi.org/10.1002/pan3.10038>
- Fountain-Jones NM, et al. 2018. Towards an eco-phylogenetic framework for infectious disease ecology. *Biological Reviews* 93: 950–970. <https://doi.org/10.1111/brv.12380>
- Freire-Paspuel B, Vega-Mariño P, Velez A, Castillo P, Masaquiza C, Cedeño-Vega R, Lozada T, Cruz M, García-Bereguain MA. 2020. "One health" inspired SARS-CoV-2 surveillance: The Galapagos Islands experience. *One Health* 11: 100185. <https://doi.org/10.1016/j.onehlt.2020.100185>
- Fukami T, Wardle DA, Bellingham PJ, Mulder CPH, Towns DR, Yeates GW, Bonner KI, Durrett MS, Grant-Hoffman MN, Williamson WM. 2006. Above- and below-ground impacts of introduced predators in seabird-dominated island ecosystems. *Ecology Letters* 9: 1299–1307. <https://doi.org/10.1111/j.1461-0248.2006.00983.x>
- Gamarrá-Toledo V, Plaza PI, Inga G, Gutiérrez R, García-Tello O, Valdivia-Ramírez L, Huamán-Mendoza D, Nieto-Navarrete JC, Ventura S, Lambertucci SA. 2023. Mass mortality of sea lions caused by highly pathogenic Avian Influenza A(H5N1) Virus. *Emerging Infectious Diseases* 29: 2553–2556. <https://doi.org/10.3201/eid2912.230192>
- Garlock T, Asche F, Anderson J, Ceballos-Concha A, Love DC, Osmundsen TC, Pincinato RBM. 2022. Aquaculture: The missing contributor in the food security agenda. *Global Food Security* 32: 100620. <https://doi.org/10.1016/j.gfs.2022.100620>
- Garrett JK, Clitherow TJ, White MP, Wheeler BW, Fleming LE. 2019. Coastal proximity and mental health among urban adults in England: The moderating effect of household income. *Health and Place* 59: 102200. <https://doi.org/10.1016/j.healthplace.2019.102200>
- Gilbert M, Xiao X, Robinson TP. 2017. Intensifying poultry production systems and the emergence of avian influenza in China: A "one Health/Ecohealth" epitome. *Archives of Public Health* 75: 48. <https://doi.org/10.1186/s13690-017-0218-4>
- Goïc NL, Hégaret H, Fabioux C, Miner P, Suquet M, Lambert C, Soudant P. 2013. Impact of the toxic dinoflagellate *Alexandrium catenella* on pacific oyster reproductive output: Application of flow cytometry assays on spermatozoa. *Aquatic Living Resources* 26: 221–228. <https://doi.org/10.1051/alr/2013047>
- Goulding W, Moss PT, McAlpine CA. 2016. Cascading effects of cyclones on the biodiversity of Southwest Pacific islands. *Biological Conservation* 193: 143–152. <https://doi.org/10.1016/j.biocon.2015.11.022>
- Graham NR, Krehenwinkel H, Lim JY, Staniczenko P, Callaghan J, Andersen JC, Gruner DS, Gillespie RG. 2023a. Ecological network structure in response to community assembly processes over evolutionary time. *Molecular Ecology* 32: 6489–6506. <https://doi.org/10.1111/mec.16873>
- Graham SB, Machalaba C, Baum SE, Raufman J, Hill SE. 2023b. Applying a One Health lens to understanding the impact of climate and environmental change on healthcare-associated infections. *Antimicrobial Stewardship and Healthcare Epidemiology* 3: e93. <https://doi.org/10.1017/ash.2023.159>
- Grant PR. 1968. Bill size, body size, and the ecological adaptations of bird species to competitive situations on islands. *Systematic Zoology* 17: 319–333. <https://doi.org/10.2307/2412010>
- Gravel D, Massol F, Canard E, Mouillot D, Mouquet N. 2011. Trophic theory of island biogeography. *Ecology Letters* 14: 1010–1016. <https://doi.org/10.1111/j.1461-0248.2011.01667.x>
- Guernier V, Goarant C, Benschop J, Lau CL. 2018. A systematic review of human and animal leptospirosis in the Pacific Islands reveals pathogen and reservoir diversity. *PLOS Neglected Tropical Diseases* 12: e0006503. <https://doi.org/10.1371/journal.pntd.0006503>
- Haberkorn H, Lambert C, Le Goïc N, Guéguen M, Moal J, Palacios E, Lassus P, Soudant P. 2010. Effects of *Alexandrium minutum* exposure upon physiological and hematological variables of diploid and triploid oysters, *Crassostrea gigas*. *Aquatic Toxicology* 97: 96–108. <https://doi.org/10.1016/j.aquatox.2009.12.006>
- Hallegraeff G, Enevoldsen H, Zingone A. 2021a. Global harmful algal bloom status reporting. *Harmful Algae* 102: 101992. <https://doi.org/10.1016/j.hal.2021.101992>
- Hallegraeff GM, et al. 2021b. Perceived global increase in algal blooms is attributable to intensified monitoring and emerging bloom impacts. *Communications Earth and Environment* 2: 117. <https://doi.org/10.1038/s43247-021-00178-8>
- Hamer RP, Andersen GE, Hradsky BA, Troy SN, Gardiner RZ, Johnson CN, Jones ME. 2021. Differing effects of productivity on home-range size and population density of a native and an invasive mammalian carnivore. *Wildlife Research* 49: 158–168. <https://doi.org/10.1071/WR20134>
- Hanna JN, Ritchie SA, Phillips DA, Shield J, Bailey MC, Mackenzie JS, Poidinger M, McCall BJ, Mills PJ. 1996. An outbreak of Japanese encephalitis in the Torres Strait, Australia 1995. *Medical Journal of Australia* 165: 256–260. <https://doi.org/10.5694/j.1326-5377.1996.tb124960.x>
- Harley D, Sleigh A, Ritchie S. 2001. Ross River virus transmission, infection, and disease: A cross-disciplinary review. *Clinical Mi-*

- crobiology Reviews 14: 909–932. <https://doi.org/10.1128/CMR.14.4.909-932.2001>
- Harlock M, Quinn S, Turnbull AR. 2022. Emergence of non-cholerae *Vibrio* infections in Australia. *Communicable Diseases Intelligence* 46: 8. <https://doi.org/10.33321/cdi.2022.46.8>
- Harrison S, et al. 2020. One Health Aotearoa: A transdisciplinary initiative to improve human, animal and environmental health in New Zealand. *One Health Outlook* 2: 4. <https://doi.org/10.1186/s42522-020-0011-0>
- Hatosy SM, Martiny AC. 2015. The ocean as a global reservoir of antibiotic resistance genes. *Applied and Environmental Microbiology* 81: 7593–7599. <https://doi.org/10.1128/AEM.00736-15>
- Heng S-P, Letchumanan V, Deng C-Y, Ab Mutalib N-S, Khan TM, Chuah L-H, Chan K-G, Goh B-H, Pusparajah P, Lee L-H. 2017. *Vibrio vulnificus*: An environmental and clinical burden. *Frontiers in Microbiology* 8: 997. <https://doi.org/10.3389/fmicb.2017.00997>
- Hewitt R, Willingham AL. 2019. Status of schistosomiasis elimination in the Caribbean Region. *Tropical Medicine and Infectious Disease* 4: 24. <https://doi.org/10.3390/tropicalmed4010024>
- Hindell MA, et al. 2020. Tracking of marine predators to protect Southern Ocean ecosystems. *Nature* 580: 87–92. <https://doi.org/10.1038/s41586-020-2126-y>
- Hoegh-Guldberg O, et al. 2019. Impacts of 1.5°C of global warming on natural and human systems. Pages 175–311 in Masson-Delmotte V, et al., eds. *Global Warming of 1.5°C: An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Intergovernmental Panel on Climate Change.
- Holbrook NJ, Hernaman V, Koshiba S, Lako J, Kajtar JB, Amosa P, Singh A. 2022. Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities. *Global and Planetary Change* 208: 103680. <https://doi.org/10.1016/j.gloplacha.2021.103680>
- Hollings T, Jones M, Mooney N, McCallum H. 2014. Trophic cascades following the disease-induced decline of an apex predator, the Tasmanian devil. *Conservation Biology* 28: 63–75. <https://doi.org/10.1111/cobi.12152>
- Huang ZYX, et al. 2019. Contrasting effects of host species and phylogenetic diversity on the occurrence of HPAI H5N1 in European wild birds. *Journal of Animal Ecology* 88: 1044–1053. <https://doi.org/10.1111/1365-2656.12997>
- Iossa G, White PC. 2018. The natural environment: A critical missing link in national action plans on antimicrobial resistance. *Bulletin of the World Health Organization* 96: 858–860. <https://doi.org/10.2471/BLT.18.210898>
- Johnson CR, et al. 2011. Climate change cascades: Shifts in oceanography, species' ranges and subtidal marine community dynamics in eastern Tasmania. *Journal of Experimental Marine Biology and Ecology* 400: 17–32. <https://doi.org/10.1016/j.jembe.2011.02.032>
- Johnson PTJ, Rohr JR, Hoverman JT, Kellermanns E, Bowerman J, Lunde KB. 2012. Living fast and dying of infection: Host life history drives interspecific variation in infection and disease risk. *Ecology Letters* 15: 235–242. <https://doi.org/10.1111/j.1461-0248.2011.01730.x>
- Jones JB, Hyatt AD, Hine PM, Whittington RJ, Griffin DA, Bax NJ. 1997. Australasian pilchard mortalities. *World Journal of Microbiology and Biotechnology* 13: 383–392. <https://doi.org/10.1023/A:1018568031621>
- Kane HH, Fletcher CH. 2020. Rethinking reef island stability in relation to anthropogenic sea level rise. *Earth's Future* 8: e2020EF001525. <https://doi.org/10.1029/2020EF001525>
- Keesing F, Holt RD, Ostfeld RS. 2006. Effects of species diversity on disease risk. *Ecology Letters* 9: 485–498. <https://doi.org/10.1111/j.1461-0248.2006.00885.x>
- Kim H, Ryan A, Harding AB, Moskowicz AF, Passe AI, Kawazu EC. 2022. Health risks of climate change in the 21 Pacific Island states and noted gaps in scientific evidence: A scoping review. *Journal of Climate Change and Health* 8: 100166. <https://doi.org/10.1016/j.joclhm.2022.100166>
- Klaassen M, Wille M. 2023. The plight and role of wild birds in the current bird flu panzootic. *Nature Ecology and Evolution* 7: 1541–1542. <https://doi.org/10.1038/s41559-023-02182-x>
- Knief U, et al. 2024. Highly pathogenic avian influenza causes mass mortality in Sandwich tern (*Thalasseus sandvicensis*) breeding colonies across northwestern Europe. *Bird Conservation International* 34: 6.
- Koolhof IS, Carver S. 2017. Epidemic host community contribution to mosquito-borne disease transmission: Ross River virus. *Epidemiology and Infection* 145: 656–666. <https://doi.org/10.1017/S0950268816002739>
- Koutsoumanis K, et al. 2021. Role played by the environment in the emergence and spread of antimicrobial resistance (AMR) through the food chain. *EFSA Journal* 19: e06651. <https://doi.org/10.2903/j.efsa.2021.6651>
- Kulp SA, Strauss BH. 2019. New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. *Nature Communications* 10: 4844. <https://doi.org/10.1038/s41467-019-12808-z>
- Kvitek RG, DeGunge AR, Beitler MK. 1991. Paralytic shellfish poisoning toxins mediate feeding behavior of sea otters. *Limnology and Oceanography* 36: 393–404. <https://doi.org/10.4319/lo.1991.36.2.0393>
- Lako JV, Naisilisili S, Vuki VC, Kuridrani N, Agyei D. 2023. Local and traditional ecological knowledge of fish poisoning in Fiji. *Toxins* 15: 223. <https://doi.org/10.3390/toxins15030223>
- Lau CL, Mayfield HJ, Lowry JH, Watson CH, Kama M, Nilles EJ, Smith CS. 2017. Unravelling infectious disease eco-epidemiology using Bayesian networks and scenario analysis: A case study of leptospirosis in Fiji. *Environmental Modelling and Software* 97: 271–286.
- Lau CL, Smythe LD, Craig SB, Weinstein P. 2010. Climate change, flooding, urbanisation, and leptospirosis: Fuelling the fire? *Transactions of the Royal Society of Tropical Medicine and Hygiene* 104: 631–638. <https://doi.org/10.1016/j.trstmh.2010.07.002>
- Lau CL, Watson CH, Lowry JH, David MC, Craig SB, Wynwood SJ, Kama M, Nilles EJ. 2016. Human leptospirosis infection in Fiji: An eco-epidemiological approach to identifying risk factors and environmental drivers for transmission. *PLOS Neglected Tropical Diseases* 10: e0004405. <https://doi.org/10.1371/journal.pntd.0004405>
- Lavers JL, Bond AL. 2013. Contaminants in indigenous harvests of apex predators: The Tasmanian short-tailed Shearwater as a case study. *Ecotoxicology and Environmental Safety* 95: 78–82. <https://doi.org/10.1016/j.ecoenv.2013.05.021>
- Layton C, Coleman MA, Marzinelli EM, Steinberg PD, Swearer SE, Vergés A, Wernberg T, Johnson CR. 2020. Kelp Forest restoration in Australia. *Frontiers in Marine Science* 7: 74. <https://doi.org/10.3389/fmars.2020.00074>
- Leal Filho W, Luetz JM, Nunn PD, Turagabeci A, Campbell D. 2024. Effective domestic climate policies to protect small island states. *Nature Climate Change* 14: 660–661. <https://doi.org/10.1038/s41558-024-02005-2>
- Leguia M, et al. 2023. Highly pathogenic avian influenza A (H5N1) in marine mammals and seabirds in Peru. *Nature Communications* 14: 5489. <https://doi.org/10.1038/s41467-023-41182-0>

- Li W, Liu C, Ho HC, Shi L, Zeng Y, Yang X, Xia H, Zhang W, Huang C, Yang L. 2023. Estimating the effect of increasing ambient temperature on antimicrobial resistance in China: A nationwide ecological study with the difference-in-differences approach. *Science of the Total Environment* 882: 163518. <https://doi.org/10.1016/j.scitotenv.2023.163518>
- Li X, Wu Z, Dang C, Zhang M, Zhao B, Cheng Z, Chen L, Zhong Z, Ye Y, Xia Y. 2021. A metagenomic-based method to study hospital air dust resistome. *Chemical Engineering Journal* 406: 126854. <https://doi.org/10.1016/j.cej.2020.126854>
- Loftus MJ, et al. 2020. Antimicrobial resistance in the Pacific Island countries and territories. *BMJ Global Health* 5: e002418. <https://doi.org/10.1136/bmjgh-2020-002418>
- Longdon B, Hadfield JD, Webster CL, Obbard DJ, Jiggins FM. 2011. Host phylogeny determines viral persistence and replication in novel hosts. *PLOS Pathogens* 7: e1002260. <https://doi.org/10.1371/journal.ppat.1002260>
- Luiken REC, et al. 2022. Determinants for antimicrobial resistance genes in farm dust on 333 poultry and pig farms in nine European countries. *Environmental Research* 208: 112715. <https://doi.org/10.1016/j.envres.2022.112715>
- Lv X, et al. 2022. Highly pathogenic avian influenza A(H5N8) clade 2.3.4.4b viruses in satellite-tracked wild ducks, Ningxia, China 2020. *Emerging Infectious Diseases* 28: 1039–1042. <https://doi.org/10.3201/eid2805.211580>
- Macarthur RH, Wilson EO. 1967. *The Theory of Island Biogeography*, revised. Princeton University Press.
- Mackenzie JS, McKinnon M, Jeggo M. 2014. One Health: From concept to practice. Pages 163–189 in Yamada A, Kahn LH, Kaplan B, Monath TP, Woodall J Conti L, eds. *Confronting Emerging Zoonoses*. Springer. [https://doi.org/10.1007/978-4-431-55120-1\\_8](https://doi.org/10.1007/978-4-431-55120-1_8)
- Mavian C, Dulcey M, Munoz O, Salemi M, Vittor AY, Capua I. 2018. Islands as hotspots for emerging mosquito-borne viruses: A One-Health perspective. *Viruses*. 11: 11. <https://doi.org/10.3390/v11010011>
- McCallum H, Harvell D, Dobson A. 2003. Rates of spread of marine pathogens. *Ecology Letters* 6: 1062–1067. <https://doi.org/10.1046/j.1461-0248.2003.00545.x>
- McGrath G, Abernethy D, Stringer L, More S. 2009. An all-island approach to mapping bovine tuberculosis in Ireland. *Irish Veterinary Journal* 62: 192–197. <https://doi.org/10.1186/2046-0481-62-3-192>
- McLeod C, et al. 2017. Accumulation and depuration of paralytic shellfish toxins by Australian abalone *Haliotis rubra*: Conclusive association with *Gymnodinium catenatum* dinoflagellate blooms. *Food Control* 73: 971–980. <https://doi.org/10.1016/j.foodcont.2016.10.012>
- Meumann EM, Mitchell BG, McGregor A, McBryde E, Cooley L. 2015. Urinary *Escherichia coli* antimicrobial susceptibility profiles and their relationship with community antibiotic use in Tasmania, Australia. *International Journal of Antimicrobial Agents* 46: 389–393. <https://doi.org/10.1016/j.ijantimicag.2015.05.015>
- Miller RJ, Colodey AG. 1983. Widespread mass mortalities of the green sea urchin in Nova Scotia, Canada. *Marine Biology* 73: 263–267. <https://doi.org/10.1007/BF00392252>
- Mologni F, Burns KC. 2023. The island biogeography of human population size. *Proceedings of the Royal Society B* 290: 20222084. <https://doi.org/10.1098/rspb.2022.2084>
- Mordecai EA, Ryan SJ, Caldwell JM, Shah MM, LaBeaud AD. 2020. Climate change could shift disease burden from malaria to arboviruses in Africa. *Lancet Planetary Health* 4: e416–e423. [https://doi.org/10.1016/S2542-5196\(20\)30178-9](https://doi.org/10.1016/S2542-5196(20)30178-9)
- Moré E, Ayats T, Ryan PG, Naicker PR, Keddy KH, Gaglio D, Witteveen M, Cerdà-Cuellar M. 2017. Seabirds (Laridae) as a source of *Campylobacter* spp., *Salmonella* spp. and antimicrobial resistance in South Africa. *Environmental Microbiology* 19: 4164–4176. <https://doi.org/10.1111/1462-2920.13874>
- Muhammad-Bashir B, Halimah BA. 2022. Challenges and future perspectives for the application of One Health. Pages 329–343 in Prata JC, Ribeiro AI Rocha-Santos T, eds. *One Health*. Academic Press.
- Murphy MM, Jeyaseelan SM, Howitt C, Greaves N, Harewood H, Quimby KR, Sobers N, Landis RC, Roche KD, Hambleton IR. 2020. COVID-19 containment in the Caribbean: The experience of small island developing states. *Research in Globalization* 2: 100019. <https://doi.org/10.1016/j.resglo.2020.100019>
- Murray AG, O'Callaghan M, Jones B. 2001. Simple models of massive epidemics of herpesvirus in Australian (and New Zealand) pilchards. *Environment International* 27: 243–248. [https://doi.org/10.1016/S0160-4120\(01\)00093-9](https://doi.org/10.1016/S0160-4120(01)00093-9)
- Naing C, Reid SA, Aye SN, Htet NH, Ambu S. 2019. Risk factors for human leptospirosis following flooding: A meta-analysis of observational studies. *PLOS ONE* 14: e0217643. <https://doi.org/10.1371/journal.pone.0217643>
- Nash KL, et al. 2022. Oceans and society: Feedbacks between ocean and human health. *Reviews in Fish Biology and Fisheries* 32: 161–187. <https://doi.org/10.1007/s11160-021-09669-5>
- Navarro JM, Duarte C, Manríquez PH, Lardies MA, Torres R, Acuña K, Vargas CA, Lagos NA. 2016. Ocean warming and elevated carbon dioxide: Multiple stressor impacts on juvenile mussels from southern Chile. *ICES Journal of Marine Science* 73: 764–771. <https://doi.org/10.1093/icesjms/fsv249>
- Neddermeyer JH, Parise KL, Dittmar E, Kilpatrick AM, Foster JT. 2023. Nowhere to fly: Avian malaria is ubiquitous from ocean to summit on a Hawaiian island. *Biological Conservation* 279: 109943. <https://doi.org/10.1016/j.biocon.2023.109943>
- Nelson BD, Ahn R, Markovchick V, Hines RA, Lauretti JR, Lauretti JR, Dahl-Regis M, Burke TF. 2015. Emergency care and referral among isolated island populations in the Bahamas. *Journal of Emergency Medicine* 48: 356–365. <https://doi.org/10.1016/j.jemermed.2014.09.069>
- Norman R, Bowers RG, Begon M, Hudson PJ. 1999. Persistence of tick-borne virus in the presence of multiple host species: Tick reservoirs and parasite mediated competition. *Journal of Theoretical Biology* 200: 111–118. <https://doi.org/10.1006/jtbi.1999.0982>
- Norman SA, Palić D, Savage ACNP, Plön S, Shields S, Venegas C. 2023. Editorial: Aquatic One Health: The intersection of marine wildlife health, public health, and our oceans. *Frontiers in Marine Science* 10: 1227121. <https://doi.org/10.3389/fmars.2023.1227121>
- Oliver JD. 2015. The biology of *Vibrio vulnificus*. *Microbiology Spectrum* 3: 1–2014. <https://doi.org/10.1128/microbiolspec.VE-0001-2014>
- O'Meara L, et al. 2023. Pacific Food Systems: The Role of Fish and Other Aquatic Foods for Nutrition and Health. Food and Agriculture Organization of the United Nations.
- Ostfeld RS, Keesing F. 2000. Biodiversity and disease risk: The case of Lyme disease. *Conservation Biology* 14: 722–728. <https://doi.org/10.1046/j.1523-1739.2000.99014.x>
- Pappas G, Papadimitriou P, Siozopoulou V, Christou L, Akritidis N. 2008. The globalization of leptospirosis: Worldwide incidence trends. *International Journal of Infectious Diseases* 12: 351–357. <https://doi.org/10.1016/j.ijid.2007.09.011>
- Pecl GT, et al. 2014. Rapid assessment of fisheries species sensitivity to climate change. *Climatic Change* 127: 505–520. <https://doi.org/10.1007/s10584-014-1284-z>
- Penn G, Carmo LP, Boriani E, Gallagher M, Piper C, Berezowski J, McMahon BJ, Jaenisch T. 2024. General ecosystem health indica-

- tors: A scoping review. *CABI One Health* 3. <https://doi.org/10.1079/cabionehealth.2024.0006>
- Perez J, Brescia F, Becam J, Mauron C, Goarant C. 2011. Rodent abundance dynamics and leptospirosis carriage in an area of hyper-endemicity in New Caledonia. *PLOS Neglected Tropical Diseases* 5: e1361. <https://doi.org/10.1371/journal.pntd.0001361>
- Pernetta JC, Watling D. 1978. The introduced and native terrestrial vertebrates of Fiji. *Pacific Science* 32: 223–244.
- Pickering J, Norris CA. 1996. New evidence concerning the extinction of the endemic Murid *Rattus macleari* from Christmas Island, Indian Ocean. *Mammalogy* 19: 19–25. <https://doi.org/10.1071/AM96019>
- Pointier JP, Jourdan J. 2000. Biological control of the snail hosts of schistosomiasis in areas of low transmission: The example of the Caribbean area. *Acta Tropica* 77: 53–60. [https://doi.org/10.1016/S0001-706X\(00\)00123-6](https://doi.org/10.1016/S0001-706X(00)00123-6)
- Pörtner H. 2012. Integrating climate-related stressor effects on marine organisms: Unifying principles linking molecule to ecosystem-level changes. *Marine Ecological Progress Series* 470: 273–290. <https://doi.org/10.3354/meps10123>
- Pouille M-L, et al. 2021. Exposure of pelagic seabirds to toxoplasma gondii in the Western Indian Ocean points to an open sea dispersal of this terrestrial parasite. *PLOS ONE* 16: e0255664. <https://doi.org/10.1371/journal.pone.0255664>
- Reid SA, Rodney A, Kama M, Hill PS. 2017. A process for developing multisectoral strategies for zoonoses: The case of leptospirosis in Fiji. *BMC Public Health* 17: 671. <https://doi.org/10.1186/s12889-017-4673-1>
- Roberts JO, Jones HFE, Roe WD. 2020. The effects of *Toxoplasma gondii* on New Zealand wildlife: Implications for conservation and management. *Pacific Conservation Biology* 27: 208. <https://doi.org/10.1071/PC20051>
- Robbins K, O'Donnell G, Neumann A, Schmidt W, Hart A, Graham DW. 2024. Antimicrobial resistance in rural rivers: Comparative study of the Coquet (Northumberland) and Eden (Cumbria) River catchments. *Science of the Total Environment* 928: 172348.
- Rolton A, Rhodes L, Hutson KS, Biessy L, Bui T, MacKenzie L, Symonds JE, Smith KF. 2022. Effects of harmful algal blooms on fish and shellfish species: A case study of New Zealand in a changing environment. *Toxins* 14: 341. <https://doi.org/10.3390/toxins14050341>
- Roth A, Mercier A, Lepers C, Hoy D, Duituturaga S, Benyon E, Guillamot L, Soares Y. 2014. Concurrent outbreaks of dengue, chikungunya and Zika virus infections: An unprecedented epidemic wave of mosquito-borne viruses in the Pacific 2012–2014. *Eurosurveillance* 19: 20929. <https://doi.org/10.2807/1560-7917.ES2014.19.41.20929>
- Seetahal JFR, et al. 2018. Rabies in the Caribbean: A Situational Analysis and Historic Review. *Trop Med Infect Dis* 3: 89. <https://doi.org/10.3390/tropicalmed3030089>
- Seeger RM, Hagerman AD, Johnson KK, Pendell DL, Marsh TL. 2021. When poultry take a sick leave: Response costs for the 2014–2015 highly pathogenic avian influenza epidemic in the USA. *Food Policy* 102: 102068. <https://doi.org/10.1016/j.foodpol.2021.102068>
- Seeger A, Hallegraeff G, Stone DAJ, Bansemmer MS, Harwood DT, Turnbull A. 2020. Uptake of paralytic shellfish toxins by blacklip abalone (*Haliotis rubra* Leach) from direct exposure to *Alexandrium catenella* microalgal cells and toxic aquaculture feed. *Harmful Algae* 99: 101925. <https://doi.org/10.1016/j.hal.2020.101925>
- Shocket MS, Ryan SJ, Mordecai EA. 2018. Temperature explains broad patterns of Ross River virus transmission. *Elife* 7: e37762. <https://doi.org/10.7554/eLife.37762>
- Singh AK, Kaur R, Verma S, Singh S. 2022. Antimicrobials and antibiotic resistance genes in water bodies: Pollution, risk, and control. *Frontiers in Environmental Science* 10: 830861. <https://doi.org/10.3389/fenvs.2022.830861>
- Starr M, et al. 2017. Multispecies mass mortality of marine fauna linked to a toxic dinoflagellate bloom. *PLOS ONE* 12: e0176299. <https://doi.org/10.1371/journal.pone.0176299>
- Strøm M, Kristiansen MF, Christiansen DH, Weihe P, Petersen MS. 2021. Elimination of COVID-19 in the Faroe Islands: Effectiveness of massive testing and intensive case and contact tracing. *Lancet Regional Health—Europe* 1: 100011. <https://doi.org/10.1016/j.lanepe.2020.100011>
- Swail V, Grimes S, Pilon P, Canterford R, Barrett C, Simonov Y. 2019. Early warnings of coastal inundation. *World Meteorological Organization Bulletin* 68. <https://public.wmo.int/en/resources/bulletin/early-warnings-of-coastal-inundation> (accessed on 20 January 2024)
- Tortosa P, Pascalis H, Guernier V, Cardinale E, Le Corre M, Goodman SM, Dellagi K. 2012. Deciphering arboviral emergence within insular ecosystems. *Infection, Genetics, and Evolution* 12: 1333–1339. <https://doi.org/10.1016/j.meegid.2012.03.024>
- Traveset A, Heleno R, Chamorro S, Vargas P, McMullen CK, Castro-Urgal R, Nogales M, Herrera HW, Olesen JM. 2013. Invaders of pollination networks in the Galápagos Islands: Emergence of novel communities. *Proceedings of the Royal Society B* 280: 20123040. <https://doi.org/10.1098/rspb.2012.3040>
- Trinanes J, Martinez-Urtaza J. 2021. Future scenarios of risk of *Vibrio* infections in a warming planet: A global mapping study. *Lancet Planetary Health* 5: e426–e435. [https://doi.org/10.1016/S2542-5196\(21\)00169-8](https://doi.org/10.1016/S2542-5196(21)00169-8)
- Turner JT. 2014. Planktonic marine copepods and harmful algae. *Harmful Algae* 32: 81–93. <https://doi.org/10.1016/j.hal.2013.12.001>
- UNCD. 1994. *Report of the global conference on the sustainable development of small island developing states*. Bridgetown Barbados.
- van den Hurk AF, Skinner E, Ritchie SA, Mackenzie JS. 2022. The emergence of Japanese encephalitis virus in Australia in 2022: Existing knowledge of Mosquito vectors. *Viruses* 14: 1208. <https://doi.org/10.3390/v14061208>
- Vanstreels R, Uhart M, Work TM. 2023. Health and diseases. Pages 131–176 in Young L VanderWerf E, eds. *Conservation of Marine Birds*. Academic Press. <https://doi.org/10.1016/B978-0-323-88539-3.00003-0>
- Veron S, Mouchet M, Govaerts R, Haevermans T, Pellens R. 2019. Vulnerability to climate change of islands worldwide and its impact on the tree of life. *Scientific Reports* 9: 14471. <https://doi.org/10.1038/s41598-019-51107-x>
- Walsh KJE, Camargo SJ, Knutson TR, Kossin J, Lee T-C, Murakami H, Patricola C. 2019. Tropical cyclones and climate change. *Tropical Cyclone Research and Review* 8: 240–250. <https://doi.org/10.1016/j.tcr.2020.01.004>
- Wang YXG, Matson KD, Prins HHT, Xu Y, Huang ZYX, de Boer WF. 2023. Risk factors for Lyme disease: A scale-dependent effect of host species diversity and a consistent negative effect of host phylogenetic diversity. *Ticks and Tick-borne Diseases* 14: 102073. <https://doi.org/10.1016/j.ttbdis.2022.102073>
- Warren BH, et al. 2015. Islands as model systems in ecology and evolution: Prospects fifty years after MacArthur-Wilson. *Ecology Letters* 18: 200–217. <https://doi.org/10.1111/ele.12398>
- Webster JP, Gower CM, Knowles SCL, Molyneux DH, Fenton A. 2016. One Health: An ecological and evolutionary framework for tackling neglected zoonotic diseases. *Evolutionary Applications* 9: 313–333. <https://doi.org/10.1111/eva.12341>

- Whetten P, Ekström M, Gerbing C, Grose M, Bhend J, Webb L, Risbey J. 2015. *Climate Change in Australia: Projections for Australia's NRM Regions*. Commonwealth Scientific and Industrial Research Organisation.
- Whittaker RJ, Fernández-Palacios JM, Matthews TJ, Borregaard MK, Triantis KA. 2017. Island biogeography: Taking the long view of nature's laboratories. *Science* 357: eaam8326. <https://doi.org/10.1126/science.aam8326>
- World Health Organization. 2014. *Antimicrobial resistance: global report on surveillance*. World Health Organization.
- [WHO] World Health Organization. 2020. Risk Assessment Tools for *Vibrio parahaemolyticus* and *Vibrio vulnificus* Associated with Seafood. WHO. Microbiological Risk Assessment series vol. 20.
- [WHO] World Health Organization. 2022. *One Health*. WHO (9 May 2022). [www.who.int/health-topics/one-health](http://www.who.int/health-topics/one-health)
- Wiens JJ. 2023. How many species are there on Earth? Progress and problems. *PLOS Biology* 21: e3002388. <https://doi.org/10.1371/journal.pbio.3002388>
- Wikelski M, Foufopoulos J, Vargas H, Snell H. 2004. Galápagos birds and diseases: Invasive pathogens as threats for island species. *Ecology and Society* 9: 5. <https://doi.org/10.5751/ES-00605-090105>
- Woodworth BL, et al. 2005. Host population persistence in the face of introduced vector-borne diseases: Hawaii amakihi and avian malaria. *Proceedings of the National Academy of Sciences* 102: 1531–1536. <https://doi.org/10.1073/pnas.0409454102>
- Worden PJ, et al. 2022. Phylogenomic diversity of *Vibrio* species and other gammaproteobacteria isolated from Pacific oysters (*Crassostrea gigas*) during a summer mortality outbreak. *Microbial Genomics* 8: 000883. <https://doi.org/10.1099/mgen.0.000883>
- Wu Z, Che Y, Dang C, Zhang M, Zhang X, Sun Y, Li X, Zhang T, Xia Y. 2022. Nanopore-based long-read metagenomics uncover the resistome intrusion by antibiotic resistant bacteria from treated wastewater in receiving water body. *Water Research* 226: 119282. <https://doi.org/10.1016/j.watres.2022.119282>
- Xu N, et al. 2023. A global atlas of marine antibiotic resistance genes and their expression. *Water Research* 244: 120488. <https://doi.org/10.1016/j.watres.2023.120488>
- Yopa DS, Massom DM, Kiki GM, Sophie RW, Fasine S, Thiam O, Zinaba L, Ngangue P. 2023. Barriers and enablers to the implementation of One Health strategies in developing countries: A systematic review. *Frontiers in Public Health* 11: 1252428. <https://doi.org/10.3389/fpubh.2023.1252428>
- Zinsstag J, et al. 2018. Climate change and One Health. *FEMS Microbiology Letters* 365: fny085. <https://doi.org/10.1093/femsle/fny085>

Received: March 27, 2024. Revised: August 11, 2024. Accepted: September 3, 2024

© The Author(s) 2024. Published by Oxford University Press on behalf of the American Institute of Biological Sciences. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)