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Marine Disease Impacts, Diagnosis, Forecasting, Management and Policy

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Introduction

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Marine disease impacts, diagnosis, forecasting, management and policy

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1. Introduction

As Australians were spending millions of dollars in 2014 to remove the coral-eating crown of thorns sea star from the Great Barrier Reef, sea stars started washing up dead for free along North America's Pacific Coast. Because North American sea stars are important and iconic predators in marine communities, locals and marine scientists alike were alarmed by what proved to be the world's most widespread marine mass mortality in geographical extent and species affected, especially given its mysterious cause. Investigative research using modern diagnostic techniques implicated a never-before-seen virus [1]. The virus inspired international attention to marine diseases, including this theme issue.

Infectious agents are nothing new in the ocean; pick up any marine species and you can find a parasite or a pathogen, or perhaps a dozen with no cause for alarm. In contrast, the alarm over sea star wasting disease recalls disease events that impacted marine communities in recent history. As German U-boats sank vessels around Europe in World War II, a far more cryptic fungal-induced wasting disease wiped out almost all the sea grass across the Northern Atlantic, along with the many species that depended on sea grass beds for food and shelter [2]. Then, following young Bob Marley's death to melanoma in 1980, another tragic disease almost extirpated herbivorous Caribbean *Diadema* sea urchins, hastening a transition from coral reefs to seaweed [3]. Soon after, as the Night Stalker's serial killings kept the citizens of Los Angeles awake at night, infectious withering syndrome drove the California black abalone towards extinction [4]. It is not surprising that the public and policy-makers would remain naive about marine diseases. However, for marine scientists, such sudden and unprecedented mass mortalities imply an unbalanced system or an introduced pathogen, or both. Marine diseases can compete with humans for seafood, inviting the attention of policy-makers. For instance, abalone withering syndrome heralded the California abalone fishery's demise [5]. Moreover, marine prawn and fish aquaculture create perfect conditions for disease transmission and have experienced one new pathogen after another, such that disease costs the global economy billions of dollars and has implications for food security as wild fisheries are replaced by aquaculture [6]. Furthermore, aquaculture moves diseases around the globe and exports them back into the wild, mostly within a system devoid of policy [7].

Marine disease is a neglected, but emerging field. A case in point is that the first standard marine community ecology textbook did not mention infectious diseases, but the 2014 edition has a substantial chapter on marine diseases. Still, there is no National Institutes of Health or Wellcome Trust (independent global charitable foundation, dedicated to improving health) or international professional society for marine diseases. Consequently, marine disease scientists often do not communicate in a timely manner, resulting in limited or no exchange of ideas and approaches. To help alleviate this isolation, and to assess the state of marine disease research, consider current challenges and suggest new frameworks for studying and managing marine diseases, a National Science Foundation funded Research Coordination Network brought together

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individuals with expertise in pathology, ecology, fisheries biology, oceanography, conservation biology, economics, communication and policy; each brought a different focus. Fisheries biology focuses on yield, economics considers human behaviour in the marketplace, ecology studies parasites in a natural context, oceanography investigates disease transmission and connectivity, conservation biology asks whether natural systems are at risk, communications studies what the public cares about, and policy evaluates whether existing regulations are enough to reduce disease spread and impact. All of these disciplines and specialties are needed to address the important issues of identifying, managing and understanding the impacts of marine diseases. This theme issue reflects these various perspectives and attempts an integration and synthesis of the current state of understanding of marine diseases.

2. Topics addressed in this issue

Before this theme issue, Lafferty & Harvell [8], Harvell *et al.* [9], and Lafferty *et al.* [6] reviewed general concepts and examples of marine disease and its impacts. The papers in the theme issue go further by addressing five topics related to marine diseases: impacts, diagnosis, forecasting, management and policy. The theme issue starts by focusing on how diseases impact marine organisms and populations. Guo *et al.* [10] review how marine diseases interact with the surprisingly sophisticated molluscan innate immune system, with an emphasis on how coevolved resistance degrades when animals (and their diseases) invade new regions. Eisenlord *et al.* [11] investigate the role of temperature in the sea star wasting disease epizootic and the crash of sea stars following the outbreak. Groner *et al.* [12] conclude this topic by synthesizing marine epizootic mathematical models, with a focus on sea louse–salmon interactions. Diagnosis is often a challenge for new marine diseases; a point made by Sutherland *et al.* [13] about how the cause of coral white pox disease has been a moving target for two decades, with more than one infectious agent to blame. Carnegie *et al.* [14] consider the critical role of diagnostics for effective disease policy and management, emphasizing classical histology. As a counterpoint, Burge *et al.* [15] are optimistic that modern tools add to the diagnostic tool kit, synthesizing new approaches for the reader and comparing modern and complementary classic techniques. For diseases with strong environmental drivers, forecasting might be possible. Froelich *et al.* [16] describe how risk management systems, such as for keeping seafood consumers safe from vibrio diseases, are ageing and not consistent with modern techniques and data. Maynard *et al.* [17] review temperature-sensitive marine diseases for which sea temperature monitoring might provide useful near-term forecasts and for which long-term projections are possible. Ben-Horin *et al.* [18] model the conditions under which fishing infected abalone can help reduce disease and improve yield. Lamb *et al.* [19] show that protecting corals from damage associated with fishing activities can have similar benefits. Pernet *et al.* [20] identify knowledge gaps and research that are necessary for managing disease in farmed bivalves and propose a multidisciplinary research framework to improve disease risk management. The need for effective communication with public and policy-makers to addresses marine disease issues is the focus of Schuldt *et al.* [21], who suggest how to communicate in ways that lead to effective policy. Groner *et al.* [22] conclude the theme issue with a synthesis that emphasizes the need to diagnose new diseases and determine if they have population-level impacts under various management scenarios and how these could be facilitated by appropriate policy.

3. Conclusion

Diseases are pervasive in marine ecosystems. Most are normal, but some come with enormous social, cultural and economic costs. Others affect species or ecosystems, degrading ecosystem productivity and services and affecting cultural and social systems. It is imperative that we understand impacts, effectively diagnose, and find creative ways to prevent and manage marine diseases, and to communicate these results with policy-makers and the public. A consistent and effective strategy, including key policies, for understanding and managing marine diseases will improve prevention, diagnosis and management.

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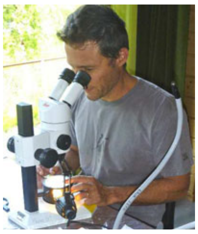
Guest Editor profiles



Kevin Lafferty is a senior ecologist with the US Geological Survey and adjunct faculty at the University of California, Santa Barbara. His main interest is on the role of infectious disease in ecosystems and how ecosystems, in turn, affect infectious diseases. Lafferty's fieldwork includes marine ecosystems such as estuaries, kelp forests and coral reefs. In addition to measuring parasites in food webs, he has studied parasites of marine invaders and parasites that affect fisheries and fisheries that affect parasites. Sometimes, his work extends to land and parasites that infect humans, such as malaria, toxoplasmosis and schistosomiasis.

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