

3-2016


Marine Disease Impacts, Diagnosis, Forecasting, Management and Policy

Kevin D. Lafferty

Eileen E. Hofmann

Old Dominion University, ehofmann@odu.edu

Follow this and additional works at: https://digitalcommons.odu.edu/ccpo_pubs

 Part of the [Ecology and Evolutionary Biology Commons](#), [Environmental Sciences Commons](#),
and the [Marine Biology Commons](#)

Repository Citation

Lafferty, Kevin D. and Hofmann, Eileen E., "Marine Disease Impacts, Diagnosis, Forecasting, Management and Policy" (2016). *CCPO Publications*. 291.

https://digitalcommons.odu.edu/ccpo_pubs/291

Original Publication Citation

Lafferty, K. D., & Hofmann, E. E. (2016). Marine disease impacts, diagnosis, forecasting, management and policy. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371(1689), 1-3. doi:10.1098/rstb.2015.0200

CrossMark
click for updates

Introduction

Cite this article: Lafferty KD, Hofmann EE. 2016 Marine disease impacts, diagnosis, forecasting, management and policy. *Phil. Trans. R. Soc. B* **371**: 20150200. <http://dx.doi.org/10.1098/rstb.2015.0200>

Accepted: 11 December 2015

One contribution of 14 to a theme issue 'Marine disease'.

Subject Areas:

ecology, environmental science, health and disease and epidemiology

Keywords:

parasite, food web, trematode

Author for correspondence:

Kevin D. Lafferty
e-mail: kevin.lafferty@lifesci.ucsb.edu

Marine disease impacts, diagnosis, forecasting, management and policy

Kevin D. Lafferty¹ and Eileen E. Hofmann²

¹Geological Survey, Western Ecological Research Center, c/o Marine Science Institute, University of California, Santa Barbara, CA 93106, USA

²Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA 23529, USA

KDL, 0000-0001-7583-4593

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

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 address 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.

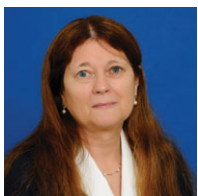
Competing interests. We declare we have no competing interests.

Funding. The Marine Disease Research Coordination Network (RCN) is funded by the National Science Foundation (grant no. OCE-1215977). This theme issue is a result of the RCN workshop held at University of Washington Friday Harbor Laboratory, which focused on marine diseases with emphasis on diagnostic techniques and sea star wasting disease.

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.



Eileen E. Hofmann is a Professor in the Department of Ocean, Earth and Atmospheric Sciences and a member for the Center for Coastal Physical Oceanography, both at Old Dominion University, Norfolk, Virginia. Her research interests are in the areas of understanding physical–biological interactions in marine ecosystems, climate control of diseases of marine shellfish populations, disease transmission in marine systems, descriptive physical oceanography and mathematical modelling of marine ecosystems. She has worked in a variety of marine environments, most recently, the Ross Sea, the eastern US continental shelf, and Delaware Bay.

References

- Hewson I *et al.* 2014 Densovirus associated with sea-star wasting disease and mass mortality. *Proc. Natl Acad. Sci. USA* **111**, 17 278–17 283. (doi:10.1073/pnas.1416625111)
- Short FT, Muehlstein LK, Porter D. 1987 Eelgrass wasting disease: cause and recurrence of a marine epidemic. *Biol. Bull.* **173**, 557–562. (doi:10.2307/1541701)
- Lessios HA. 1988 Mass mortality of *Diadema antillarum* in the Caribbean: what have we learned? *Annu. Rev. Ecol. Syst.* **19**, 371–393. (doi:10.1146/annurev.es.19.110188.002103)
- Lafferty KD, Kuris AM. 1993 Mass mortality of abalone *Haliotis cracherodii* on the California Channel Islands: tests of epidemiological hypotheses. *Mar. Ecol. Prog. Ser.* **96**, 239–248. (doi:10.3354/meps096239)
- Davis GE, Haaker PL, Parker DO. 1992 Abalone population declines and fishery management in southern California. In *Abalone of the world: biology, fisheries and culture. Proc. First Int. Symp. on Abalone* (eds SA Shepherd, MJ Tegner, SA Gusman del Proo), pp. 237–249. Cambridge, UK: Cambridge University Press.
- Lafferty KD *et al.* 2015 Infectious diseases affect marine fisheries and aquaculture economics. *Annu. Rev. Mar. Sci.* **7**, 471–496. (doi:10.1146/annurev-marine-010814-015646)
- Lafferty KD, Ben-Horin T. 2013 Abalone farm discharges the withering syndrome pathogen into the wild. *Front. Microbiol.* **4**, 373. (doi:10.3389/fmicb.2013.00373)
- Lafferty KD, Harvell CD. 2014 The role of infectious diseases in marine communities. In *Marine community ecology and conservation* (eds MD Bertness, JF Bruno, BR Silliman, JJ Stachowicz), pp. 85–108. Sunderland, MA: Sinauer Associates.
- Harvell CD *et al.* 1999 Emerging marine diseases: climate links and anthropogenic factors. *Science* **285**, 1505–1510. (doi:10.1126/science.285.5433.1505)
- Guo X, Ford SE. 2016 Infectious diseases of marine molluscs and host responses as revealed by genomic tools. *Phil. Trans. R. Soc. B* **371**, 20150206. (doi:10.1098/rstb.2015.0206)
- Eisenlord ME *et al.* 2016 Ochre star mortality during the 2014 wasting disease epizootic: role of population size structure and temperature. *Phil. Trans. R. Soc. B* **371**, 20150212. (doi:10.1098/rstb.2015.0212)
- Groner ML *et al.* 2016 Lessons from sea louse and salmon epidemiology. *Phil. Trans. R. Soc. B* **371**, 20150203. (doi:10.1098/rstb.2015.0203)
- Sutherland KP, Berry B, Park A, Kemp DW, Kemp KM, Lipp EK, Porter JW. 2016 Shifting white pox aetiologies affecting *Acropora palmata* in the Florida Keys, 1994–2014. *Phil. Trans. R. Soc. B* **371**, 20150205. (doi:10.1098/rstb.2015.0205)
- Carnegie RB, Arzul I, Bushek D. 2016 Managing marine mollusc diseases in the context of regional and international commerce: policy issues and emerging concerns. *Phil. Trans. R. Soc. B* **371**, 20150215. (doi:10.1098/rstb.2015.0215)
- Burge CA *et al.* 2016 Complementary approaches to diagnosing marine diseases: a union of the modern and the classic. *Phil. Trans. R. Soc. B* **371**, 20150207. (doi:10.1098/rstb.2015.0207)
- Froelich BA, Noble RT. 2016 *Vibrio* bacteria in raw oysters: managing risks to human health. *Phil. Trans. R. Soc. B* **371**, 20150209. (doi:10.1098/rstb.2015.0209)
- Maynard J *et al.* 2016 Improving marine disease surveillance through sea temperature monitoring, outlooks and projections. *Phil. Trans. R. Soc. B* **371**, 20150208. (doi:10.1098/rstb.2015.0208)
- Ben-Horin T, Lafferty KD, Bidegain G, Lenihan HS. 2016 Fishing diseased abalone to promote yield and conservation. *Phil. Trans. R. Soc. B* **371**, 20150211. (doi:10.1098/rstb.2015.0211)
- Lamb JB, Wenger AS, Devlin MJ, Ceccarelli DM, Williamson DH, Willis BL. 2016 Reserves as tools for alleviating impacts of marine disease. *Phil. Trans. R. Soc. B* **371**, 20150210. (doi:10.1098/rstb.2015.0210)
- Pernet F, Lupo C, Bacher C, Whittington RJ. 2016 Infectious diseases in oyster aquaculture require a new integrated approach. *Phil. Trans. R. Soc. B* **371**, 20150213. (doi:10.1098/rstb.2015.0213)
- Schuldt JP, McComas KA, Byrne SE. 2016 Communicating about ocean health: theoretical and practical considerations. *Phil. Trans. R. Soc. B* **371**, 20150214. (doi:10.1098/rstb.2015.0214)
- Groner ML *et al.* 2016 Managing marine disease emergencies in an era of rapid change. *Phil. Trans. R. Soc. B* **371**, 20150364. (doi:10.1098/rstb.2015.0364)