

Managing Marine Disease Emergencies in an Era of Rapid Change

Maya L. Groner, Jeffrey Maynard, Rachel Breyta, Ryan B. Carnegie, Andy Dobson, Carolyn S. Friedman, Brett Froelich, Melissa Garren, Frances M. D. Gulland, Scott F. Heron, Rachel T. Noble, Crawford W. Revie, Jeffrey D. Shields, Raphaël Vanderstichel, Ernesto Weil, Sandy Wyllie-Echeverria, C. Drew Harvell

Philosophical Transactions of the Royal Society of London B doi: 10.1098/rstb.2015.0364

Supplemental Material

Table 1. Examples of marine disease surveillance programs that have been implemented since 1995. Various types of agencies ranging from non-profit to state to federal to international coordinate these efforts.

Disease	Host	Pathogen	Surveillance Method	Agency*	Location
Infectious hematopoietic necrosis (IHN)	Various Finfish	IHN virus	Cell culture, neutralization tests and DNA [1]	DFO	British Columbia
Viral hemorrhagic septicemia (VHS)	Various Finfish	VHS virus	Cell culture, neutralization tests and DNA [1]	DFO	British Columbia
Bacterial Kidney disease (BKD)	Various Finfish	<i>Renibacterium salmoninarum</i>	Enzyme-linked immunosorbent assay (ELISA) on kidney tissues [1]	DFO	British Columbia
Furunculosis	Various Finfish	<i>Aeromonas salmonicida</i>	Culture on agar [1]	DFO	British Columbia
Microsporidial Gill Disease	Pacific Salmon	<i>Loma</i> spp.	Gill histology [1]	DFO	British Columbia
Epitheliocystis	Various Finfish	<i>Chlamydia</i> -like bacteria	Gill histology [1]	DFO	British Columbia
Various Bivalve diseases	Oysters and Mussels	Various including <i>Perkinsus marinus</i> , <i>Haplosporidium nelsoni</i> , trematodes	Histological analysis of major tissues [2]	NOAA, USA Mussel Watch	USA nationwide
Perkinsosis, haplosporidiosis, others	Oysters	<i>Perkinsus marinus</i> , <i>Haplosporidium nelsoni</i> , others	Chesapeake Bay, Virginia; annually in autumn; histology, Ray's fluid thioglycollate assay [3,4,5]	Universities	Mid-Atlantic
Vibriosis	Humans, concentrated in shellfish	<i>V. vulnificus</i> , <i>V. parahaemolyticus</i> , <i>V. cholerae</i>	Tracking of human illness and associated contact with shellfish [6]	CDC	USA Nationwide
Hematodinium	Blue crab, Snow crab, Tanner crab, Norway lobster	<i>Hematodinium perezii</i>	Cytology, histology, PCR [7,8,9]	NOAA, DFO, Universities, CEFAS	Mid-Atlantic, Newfoundland, Alaska, UK
Epizootic shell disease	American lobster	Bacterial dysbiosis	Macroscopic diagnosis [10,11]	State agencies and	Northeast USA

				universities	
Gaffkemia	American lobster	<i>Aerococcus viridans homari</i>	Culture, PCR, histology [12]	State and provincial agencies	NE North America
<i>Panulis argus</i> Virus 1	Caribbean spiny lobster	PaV1 virus	PCR, histology [13]	Universities	Caribbean, mostly Florida
White spot	Shrimp	White spot syndrome virus	PCR, histology [14]	Various	Pandemic
Morbillivirus	Cetaceans, Pinnipeds	Dolphin morbillivirus, Cetacean morbillivirus, Phocine distemper virus	Histology, PCR, serology [15]	NOAA, Universities	USA various coasts
Leptospirosis	California sea lions	<i>Leptospira pomona</i>	Histology, serology, PCR, Immunohistochemistry (IHC), culture [15]	TMMC, Universities	USA various coasts
Brucellosis	Marine mammals	<i>Brucella marins</i>	Histology, PCR, IHC, culture [15]	NOAA, CDC, USDA, Universities	USA various coasts
Q fever	Marine Mammals	<i>Coxiella burnetti</i>	Histology, PCR [15]	NOAA, CDC, Universities	USA various coasts
Protozoal encephalitis and myositis	Marine mammals	Protozoa	Histology, serology, IHC, PCR, culture [15]	NOAA, NIH, Universities, State Agencies	USA
Black sea urchin <i>Diadema antillarum</i> die off	Black sea urchin <i>Diadema antillarum</i>	Unidentified specific pathogen	Disease signs in field monitoring programs [16, 17, 19]	STRI, UPR NOAA, UMI, USGS other DMRPs	Wider Caribbean
Black band disease (BBD)	> 40 coral spp and some octocorals	Bacterial consortia, (cyanobacteria, sulf-oxydizing & sulfo-reducing, etc.)	Disease signs in field monitoring programs, lab cultures, histology, DNA [18, 19, 20, 21, 22]	FIU, UPR, BBSR, USGS, other DMRPs	Wider Caribbean, Indo-Pacific, Red Sea
White band disease (WBD)	Acroporid corals in the Caribbean	<i>Vibrio charchariae</i>	Disease signs in field monitoring programs, lab. cultures, DNA [19, 21, 22, 23, 24, 25]	UPR, USGS UNAM, UMI, other DMRPs	Wider Caribbean
White patches-patchy necrosis-white pox- shut down reaction	Acroporids	<i>Serratia marcesens</i> and maybe other bacteria	Disease signs in field monitoring programs, lab cultures, histology, DNA analyses [21, 25, 26]	UG, UPR, UNAM, USGS, other DMRPs	Wider Caribbean
Caribbean yellow band disease (CYBD)	12 corals species	<i>Vibrio</i> species complex	Disease signs in field monitoring programs, lab cultures, histology, DNA [19, 21, 28, 29, 30, 31, 32]	UPR, BBSR UNAM, STRI, other DMRPs	Wider Caribbean

White plague disease types (WPD)	40 corals species and two hydrocorals?	<i>Aurantimonas coralicida</i> and other bacteria	Disease signs in field monitoring programs, lab/field experimentation, DNA [19, 21, 22, 33, 34, 35]	UPR, MML, BBSR, UMI, USGS, other DMRPs	Wider Caribbean, Atlantic and Indo-Pacific
Dark spots disease (DSD)	11 coral species	Unknown, but some indication of a fungal problem	Disease signs in field monitoring programs, lab. cultures, histology DNA [19, 21, 28]	UNAM, UPR, INVEMAR, other DMRPs	Wider Caribbean and Pacific reefs
Aspergillosis (ASP)	Sea fans and other octocorals	<i>Aspergillus sidowii</i>	Disease signs in field monitoring programs, Lab cultures, histology, DNA [19, 21, 36, 37, 38, 39]	Cornell U, UPR, other DMRP's	Wider Caribbean
Red band disease (RBD)	Sea fan Octocorals and 13 coral species	Cyanobacteria - <i>Oscillatoria</i> sp. and other spp.	Disease signs in field monitoring programs, lab cultures, histology [19, 34]	UPR and other DMRPs	Wider Caribbean
Multi focal purple spots (MFPS)	Sea Fan <i>Gorgonia ventalina</i>	Protozoan – <i>Labyrinthula</i> sp.?	Disease signs in field monitoring programs, histology, lab cultures, DNA [19, 40]	Cornell U, UPR	Wider Caribbean,
Caribbean ciliate infection (CCI)	22 species of corals	<i>Halofolliculina</i> sp.	Disease signs in field monitoring programs, histology, lab cultures,, DNA [19, 41, 42]	UPR, USB and other DMRPs	Wider Caribbean
Crustose coralline white band syndrome (CWBS)	> Three species of coralline algae (CCA)	Unknown	Disease signs in field monitoring programs [19, 43, 44, 45]	UPR, USB, NOAA, other DMRP's	Wider Caribbean and Indo-Pacific
Bacterial Bleaching (BBLE)	>Three coral species	<i>Vibrio shiloi</i> , <i>V. coralliilyticus</i>	Bleaching signs, lab. cultures, DNA. {21, 46, 47]	UTA, other DMRPs	Mediterranean, Red Sea and Indian Ocean
Skeletal eroding band (SEB)	31 species of corals	Ciliate <i>Halofolliculina corallasia</i>	Disease signs in field monitoring programs, lab. observations, DNA. [20, 21, 48, 49]	AIMS. USH, UH, UGU, other DMRPs	Indo-Pacific and Red Sea
White syndrome (WS)	> 17 coral species	Proteobacteria, family Vibrionaceae	Disease signs in field monitoring programs, cultures, DNA [20, 21, 50, 51]	AIMS. USH, UGU, UH, other DMRPs	Indo-Pacific Red sea
Brown band (BrB)	Many coral species and some octocorals	Mobile ciliates, <i>Helicostoma nonatum</i> - <i>Porpostoma guamensis</i>	Disease signs in field monitoring programs, lab. cultures, DNA [20, 21, 51, 52]	AIMS. USH, UGU, UH, other DMRPs	Indo-Pacific
Yellow band disease (YBD) – (Indian Ocean and Red Sea)	12 coral spp.	<i>Vibrio</i> species-complex	Disease signs in field monitoring programs, lab. cultures, histology [21, 30, 52]	AIMS. USH, UH, other DMRPs	Arabian Gulf, Indo-Pacific

<i>Porites</i> ulcerative white spots (PUWS)	Massive and branching <i>Porites</i> spp., other spp	Unknown	Disease signs in field monitoring programs [20, 51, 53, 54]	AIMS, USH, UH, UGU, other DMRPs	Indo-Pacific
Trematodiasis (TRE)	Mostly massive <i>Porites</i> spp.	Trematode (<i>Podocotyloides stenometra</i>)	Disease signs in field monitoring programs, lab. cultures, DNA [20, 55, 56]	AIMS, USH, UH, UGU, other DMRPs	Indo-Pacific
Pink line, pink response	Massive <i>Porites</i> spp and other coral spp	Cyanobacteria (<i>Phormidium valderianum</i>), fungi and other “irritants”	Disease signs in field monitoring programs, lab. cultures histology [20, 50, 57]	AIMS, USH, UH, UGU, other DMRPs	Indo-Pacific
Growth anomalies (GAN) – Skeletal anomalies (SKA) – tumors		Endolithic fungi, algae (<i>Ento cladia endozoica</i>), trematode (<i>P. stenometra</i>)	Disease signs in field monitoring programs, lab. cultures, DNA [19, 20, 21, 59, 60, 61, 62, 63]	UPR, USGS, AIMS, USH, UH, UGU, NOAA, other DMRPs	Caribbean, Atlantic, Indo-Pacific, Red Sea
Black necrosing syndrome (BNS) and Fungal protozoan syndrome (FPS)	16 CA and 24 IP coral spp, many octocorals	Bacteria, ciliates, several fungal species	Disease signs in field monitoring, epizootic events, lab. cultures, DNA [20, 21, 64]	AIMS, USH, UH, UGU, NOAA, other DMRPs	Indo-Pacific, Red Sea, Mediterranean sea
Coralline lethal orange disease (CLOD)	Several species of octocorals	Bacterial consortium (<i>Planococcus</i> , <i>Bacillus</i> , and <i>Pseudomonas</i>)	Disease signs in field monitoring, lab cultures. DNA (19, 44, 65, 66, 67, 68, 69]	AIMS, USH, UH, UGU, NOAA, other DMRPs	Indo-Pacific, Caribbean
Coralline fungal disease (CFD)	Various CCA species	Fungus	Disease signs in field monitoring, lab. cultures [44, 70]	AIMS, USH, UH, UGU, NOAA, other DMRPs	Indo Pacific
<i>Gorgonia</i> wasting syndrome (GWS)	Sea fan <i>Gorgonia ventalina</i>	Bacteria?	Disease signs in field monitoring programs [71]	UPR	Puerto Rico
Other coral, octocoral, zoanthid and sponge health conditions (OHC)	Many species of these major coral reef groups	Unknown pathogens	Disease signs in field monitoring programs [19, 20, 21, 43, 62]	UPR, BBSR, INVEMAR, AIMS, other DMRPs	Caribbean, Indo-Pacific

* DFO-Department of Fisheries and Oceans, Canada, CDC- Center for Disease Control, USA, NIH-National Institute for Health, USA, NOAA- National Oceanic and Atmospheric Administration, USA, USDA, United States Department of Agriculture, TMMC- The Marine Mammal Center, CEFAS- Center for Environment, Fisheries and Aquaculture Science; UPR – University of Puerto Rico; BBSR- Bermuda Biological Research Station; FIU – Florida International University; STRI- Smithsonian Tropical Research Institute; UMI – University of Miami; INVEMAR- Instituto de Investigaciones Marinas, Colombia; UNAM – Universidad Autonoma de Mexico, USGS – United States Geological Survey; USB – Universidad Simon Bolivar; MML – Mote Marine Lab; UTA- University of Tel Avid; AIMS-LTMP- Australian Institute of Marine Science Long Term Monitoring Program; USH – University of Shizuoka (Japan); UH – University of Hawaii; UGU- University of Guan; DMRP’s – Coral reef Disease Monitoring Research Programs (i.e. CARICOMP, AGGRA, ALMC, etc).

Literature Cited

1. Kent ML, Traxler GS, Kieser D, *et al.* 1998. Survey of salmonid pathogens in ocean-caught fishes in British Columbia, Canada. *J Aquat Anim Health*, **10**, 211-219. (doi: 10.1577/1548-8667(1998)010<0211:SOSP>2.0.CO;2)
2. Kim Y, Powell EN. 2007 Distribution of parasites and pathologies in sentinel bivalves: NOAA status and trends “Mussel Watch” program. *J Shell Res* **26**, 1115-1151. (doi: [http://dx.doi.org/10.2983/0730-8000\(2007\)26\[1115:DOPAPI\]2.0.CO;2](http://dx.doi.org/10.2983/0730-8000(2007)26[1115:DOPAPI]2.0.CO;2))
3. Tarnowski M. 2015 Maryland oyster population status report—2014 fall survey. Maryland Department of Natural Resources, Annapolis. 68 pp.
4. Ford SE, Bushek D. 2012 Development of resistance to an introduced marine pathogen by a native host. *J Mar Res* **70**, 205-223. (doi: <http://dx.doi.org/10.1357/002224012802851922>)
5. Carnegie RB, Bureson EM. 2011 Declining impact of an introduced pathogen: *Haplosporidium nelsoni* in the oyster *Crassostrea virginica* in Chesapeake Bay. *MEPS*, **432**, 1-15. (doi: 10.3354/meps09221)
6. Centers for Disease Control and Prevention (CDC). 2012. Cholera and Other Vibrio Illness Surveillance Overview. Atlanta, Georgia: US Department of Health and Human Services, CDC.
7. Shields JD, Taylor DM, O Keefe PG, Colbourne E, Hynick E. 2007. Epidemiological determinants in outbreaks of bitter crab disease (*Hematodinium* sp.) in snow crabs *Chionoecetes opilio* from Conception Bay, Newfoundland, Canada. *Dis Aquat Org*, **77**, 61-72. (doi: 10.3354/dao01825)
8. Shields JD, Sullivan SE, Small HJ. 2015. Overwintering of the parasitic dinoflagellate *Hematodinium perezii* in dredged blue crabs (*Callinectes sapidus*) from Wachapreague Creek, Virginia. *J Invert Pathol*, **130**, 124-132. (doi: 10.1016/j.jip.2015.07.013)
9. Stentiford GD, Neil DM, Coombs GH. 2001. Development and application of an immunoassay diagnostic technique for studying *Hematodinium* infections in *Nephrops norvegicus* populations. *Dis Aquat Org*, **46**, 223-229. (doi: 10.3354/dao046223)
10. Glenn RP, Pugh TL. 2006. Epizootic shell disease in American lobster (*Homarus americanus*) in Massachusetts coastal waters: interactions of temperature, maturity, and intermolt duration. *J Crust Biol*, **26**, 639-645. (doi: 10.1651/S-2754.1)
11. Shields JD. 2013 Complex etiologies of emerging diseases in lobsters (*Homarus americanus*) from Long Island Sound. *Can J Fish Aquat Sci* **70**, 1576-1587. (doi: [org/10.1139/Cjfas-2013-0050](http://dx.doi.org/10.1139/Cjfas-2013-0050))
12. Stebbing PD, Pond MJ, Peeler E, *et al.* (2012) Limited prevalence of gaffkaemia (*Aerococcus viridans* var. *homari*) isolated from wild-caught European lobsters *Homarus gammarus* in England and Wales. *Dis Aquat Org*, **100**, 159-167. (doi: 10.3354/dao02491)
13. Moss J, Behringer D, Shields JD, *et al.* 2013. Distribution, prevalence, and genetic analysis of *Panulirus argus* virus 1 (PaV1) from the Caribbean Sea. *Dis Aquat Org*, **104**, 129-140. (doi: 10.3354/dao02589)
14. Sánchez-Paz A. 2010. White spot syndrome virus: an overview on an emergent concern. *Vet res*, **41**, 43. (doi: 10.1051/vetres/2010015)
15. Simeone CA, Gulland FMD, Norris T, Rowles TK. 2015. A Systematic Review of Changes in Marine Mammal Health in North America, 1972-2012: The Need for a Novel Integrated Approach. *PLoS One* **10**, e0142105. (doi:10.1371/journal.pone.0142105)
16. Lessios HA. 2016. The Great *Diadema antillarum* Die-Off: 30 Years Later *Annu. Rev. Mar. Sci.* **2016**, **8**, 1–17 (doi: 10.1146/annurev-marine-122414-033857).
17. Weil E, Torres JL, Ashton M. 2005. Population characteristics of the sea urchin *Diadema antillarum* in La Parguera, Puerto Rico, 17 years after the mass mortality event. *Rev Biol Trop*, **53**, 219-231
18. Richardson, L. 2004. Black band disease In E. Rosemberg and Y. Loya (Eds.) Coral reef health and diseases Pp.325-335. Springer, New York.
19. Weil E, Rogers CS. 2011. Coral Reef disease in the Atlantic-Caribbean. In Z. Dubinski and N. Stambler Eds. Coral Reefs: An Ecosystem in Transition Chapter 27. Pp. 465-492. Springer. New York.
20. Willis B, Page C, Dinsdale EA 2004. Coral disease on the Great Barrier Reef. In E. Rosemberg and Y. Loya (Eds.) Coral reef health and diseases Pp.69-104. Springer, New York.
21. Sutherland KP, Porter JW, Torres C, 2004. Disease and immunity in Caribbean and Indo-Pacific zooxanthellate corals. *Mar Ecol Prog Ser*, **266**, 273–302. (doi: 10.3354/meps266273)
22. Loya Y. 2004. The coral reefs of Eilat. Past, present and future. Three decades of coral community structure studies. In E. Rosemberg and Y. Loya (Eds.) Coral reef health and diseases Pp.1-29. Springer, New York.
23. Ritchie KB, Smith GW. 1998. Description of type II white band disease in acroporid corals. *Rev Biol Trop*, **46**, 199–203.
24. Bythel J, Pantos O, Richardson L. 2004. White plague, white band and other “white” diseases. In: Rosenberg E, Loya Y (eds) Coral health and disease. Springer, NY, pp 351-364.
25. Gil-Agudelo DL, Smith GW, Weil E. 2006. The white band disease type II pathogen in Puerto Rico. *Rev Biol Trop*, **54**(supl 3), 59-67.
26. Paterson K, Ritchie K. 2004. White Pox Disease of the Caribbean Elkhorn coral *Acropora palmata*. In Rosemberg E and Loya Y (Eds) Coral Health and Disease. Pp. 284 -297. Springer, NY

27. Rodriguez-Martinez RE, Benaszak AT, Jordan-Dahlgren E. 2001. Necrotic patches affect *Acropora palmata* (Scleractinia: Acroporidae) in the Mexican Caribbean. *Dis Aquat Org*, **47**, 229–234. (doi: 10.3354/dao047229)
28. Gil-Agudelo D, Smith GW, Garzon-Ferreira J, Weil E, Peterson D. 2004. Dark spots disease and yellow band disease, two poorly known coral diseases with high incidence in Caribbean reefs. In: Rosenberg E, Loya Y (eds) Coral health and disease. Springer, NY, pp 337–350.
29. Harvell CD, Markel S, Jordan-Dahlgren E, et al. 2007. Coral disease, environmental drivers and the balance between coral and microbial associates. *Oceanography*, **20**, 36–59. (doi: http://dx.doi.org/10.5670/oceanog.2007.91)
30. Cervino JM, Thompson FL, Gomez-Gil B, et al. 2008. *Vibrio* pathogens induce yellow band disease in Caribbean and Indo-Pacific reef-building corals. *J Appl Microbiol*, **105**, 1658–1671. (doi:10.1111/J.1365-2672.2008.03871x)
31. Bruckner AW, Hill R. 2009. Ten years of change to coral communities off Mona and Desecheo islands, Puerto Rico, from disease and bleaching. *Dis Aquat Org*, **87**, 19–31. (doi: 10.3354/dao02120)
32. Weil E, Croquer A, Urreiztieta I. 2009. Temporal variability and consequences of coral diseases and bleaching in La Parguera, Puerto Rico from 2003–2007. *Carib J Sci*, **45**, 221–246.
33. Denner EBM, Smith GW, Busse HJ, Schumann et al. 2003. *Aurantimonas corallicida* gen. nov., sp. nov., the causative agent of white plague type II on Caribbean scleractinian corals. *Int J Syst Evol Microbiol*, **53**, 1115–1122. (doi: 10.1099/ijs.0.02359-0)
34. Richardson LL. 1998. Coral diseases: what is really known? *Trends Ecol Evol*, **13**, 438–443. (doi: 10.1016/S0169-5347(98)01460-8)
35. Rogers CS, Miller J, Muller EM (2008a) Coral diseases following massive bleaching in 2005 cause 60 percent decline in coral cover and mortality of the threatened species, *Acropora palmata*, on reefs in the U.S. Virgin Islands. USGS Fact Sheet 2008–3058.
36. Nagelkerken I, Buchan K, Smith GW, et al. 2007. Widespread disease in Caribbean sea fans: I. Spreading and general characteristics. In: Proceedings of 8th international coral reef symposium, vol 1, Panama, 1997, pp 679–682
37. Smith GW, Weil E. 2004. Aspergillosis of gorgonians. In: Rosenberg E, Loya Y (eds) Coral health and disease. Springer, NY, pp 279–286.
38. Kim K, Harvell CD. 2002. Aspergillosis of sea fan corals: disease dynamics in the Florida Keys. In: Porter J, Porter K (eds) The Everglades, Florida Bay, and coral reefs of the Florida Keys, an ecosystem sourcebook. CRC Press, Boca Raton, pp 813–824.
39. Flynn K, Weil E. 2009. Variability of Aspergillosis in *Gorgonia ventalina* in La Parguera, Puerto Rico. *Carib. J Sci*, **45**, 215–220.
40. Burge CA, Douglas N, Conti-Jerpe I, et al. 2012. Friend or foe: the association of Labyrinthomycetes with the Caribbean sea fan, *Gorgonia ventalina*. *Dis Aquat Org* **101**, 1–12. (doi: 10.3354/dao02487)
41. Croquer A, Bastidas C, Lipscomb D. 2006. Folliculinid ciliates: a new threat to Caribbean corals? *Dis Aquat Org*, **69**, 75–78. (doi: 10.3354/dao069075)
42. Croquer A, Weil E. 2009. Spatial variability in distribution and prevalence of coral and octocoral diseases in the Caribbean II: genera-level analysis. *Dis Aquat Org*, **83**, 209–222. (doi: 10.3354/dao02012)
43. Weil E. 2004. Coral Reef Diseases in the Wider Caribbean. In E. Rosenberg and Y. Loya (Eds.) Coral reef health and diseases. Pp. 35–68. Springer-Verlag,
44. Ballantine D, Weil E, Ruiz H. 2005. Coralline white band syndrome: a coralline algal affliction in the tropical Atlantic. *Coral Reefs*, **24**, 117. (doi: 10.1007/s00338-004-0424-8)
45. Vargas BA. 2010. Crustose coralline algal diseases in the U.S.-Affiliated Pacific Islands. *Coral Reefs*, **29**, 943–956. (doi:10.1007/s00338-010-0646-x.)
46. Rosenberg E and Falkovitz L. 2004. The *vibrio shiloi/oculina patagonica* model system of coral bleaching. *Annu. Rev. Microbiol* 2004, **58**, 143–59. (doi: 10.1146/annurev.micro.58.030603.123610)
47. Ben-Haim Y and Rosember E. 2004. Temperature regulated bleaching and tissue lysis of *Pocillopora damicornis* by the novel pathogen *Vibrio coralliilycus*. In E. Rosemberg and Y. Loya (Eds.) Coral reef health and diseases. Pp. 301–321. Springer-Verlag,
48. Antonius A, Lipscomb D. 2001. First protozoan coral-killer identified in the Indo-Pacific. *Atoll Res Bull*, **481**, 1–21. (doi: 10.5479/si.00775630.481)
49. Winkler R, Antonius A, Renegar DA, 2004. The Skeleton Eroding Band Disease on Coral Reefs of Aqaba, Red Sea. *Mar Ecol*, **25**, 129–144. (doi: 10.1111/j.1439-0485.2004.00020.x)
50. Sussman M, Willis B, Victor S, Bourne DG 2008. Coral Pathogens Identified for White Syndrome (WS) Epizootics in the Indo-Pacific. *PLoS one*, **3**, e2393. (doi:10.1371/journal.pone.0002393)
51. Weil E, Casareto B, Irikawa A, Suzuki Y. 2012. Extended geographic distribution of several Indo-Pacific coral reef diseases. *Dis Aquat Org*, **98**, 163–170. (doi: 10.3354/dao02433)
52. Korrubel JL, Riegl B. 1998. A new coral disease from the Arabian Gulf. *Coral Reefs*, **17**, 22. (doi: 10.1007/s003380050088)
53. Raymundo LJH, Harvell CD, Reynolds TL. 2003. *Porites* ulcerative white spot disease, description, prevalence and host range of a new coral disease affecting Indo-Pacific reefs. *Dis Aquat Org*, **56**, 95–104. (doi: 10.3354/dao056095)

54. Raymundo LJH, Rosell KB, Reboton CT, Kaczmarek L, 2005. Coral diseases on Philippine reefs: genus *Porites* is a dominant host. *Dis Aquat Org*, **64**, 181–191. (doi:10.3354/dao064181)
55. Aeby, GS, 1998. A digenean metacercaria from the reef coral, *Porites compressa*, experimentally identified as *Podocotyloides stenometra*. *J Parasitol*, **84**, 1259–1261.
56. Aeby, GS. 2003. Corals in the genus *Porites* are susceptible to infection by a larval trematode. *Coral Reefs*, **22**, 216. (doi: 10.1007/s00338-003-0310-9)
57. Ravindran J, Raghukumar C. 2002. Pink line syndrome (PLS) in the scleractinian coral *Porites lutea*. *Coral Reefs*, **21**, 252. (doi: 10.1007/s00338-002-0247-4)
58. Yamashiro H. 2004. Coral diseases. In: Coral reefs of Japan. Ministry of Environment and the Japanese Coral Reef Society, Tokyo, p 56–59.
59. Squires DF. 1965. Neoplasia in a coral? *Science*, **148**, 503–505.
60. Peters EC, Halas JC, McCarty HB 1986. *Calicoblastic neoplasms* in *Acropora palmata* with a review of reports on anomalies of growth and form in corals. *J Natl Cancer Inst*, **76**, 895–912.
61. Peters EC. 1997. Diseases of coral reef organisms. In: Birkeland C (ed) Life and death of coral reefs. Chapman & Hall, New York, p 114–139.
62. Raymundo LJ, Couch CS, Harvell DC (eds) 2008. Coral disease handbook. Guidelines for assessment, monitoring and managing. GEF-CRTR Program, Currie Commission, Melbourne. 120 pp.
63. Irikawa A, Casareto BE, Suzuki Y, Hidaka M, van Woesik R. 2011. Growth anomalies on *Acropora cytherea* corals. *Mar Pollut Bull*, **62**, 1702–1707. (doi:10.1016/j.marpolbul.2011.05.033)
64. Cerrano C, Bavestrello G, Bianchi CN, *et al.* 2000. A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (Northwestern Mediterranean) summer 1999. *Ecol Lett*, **3**, 284–293. (doi: 10.1046/j.1461-0248.2000.00152.x)
65. Littler MM, Littler DS. 1994. A pathogen of reef-building coralline algae discovered in the South Pacific. *Coral Reefs*, **13**, 202. (doi: 10.1007/BF00303632)
66. Littler MM, Littler DS. 1995. Impact of CLOD pathogen on Pacific coral reefs. *Science*, **267**, 1356–1360.
67. Littler MM, Littler DS. 1997. Disease-induced mass mortality of crustose coralline algae on coral reefs provide a rationale for the conservation of herbivorous fish stocks. In: Proc. 8th Int. Coral Reef Symp, **1**, 719–724.
68. Aeby GS (2007) First record of coralline lethal orange disease (CLOD) in the Northwestern Hawaiian Islands. *Coral Reefs*, **26**, 385.
69. Cervino JM, Littler MM, Littler DS, *et al.* 2005. Identification of microbes associated with coralline lethal algal disease and its relationship to glacial ice melt (global warming). *Phytopathology*, **95**, 120–121.
70. Littler MM, Littler DS. 1998. An undescribed fungal pathogen of reef-forming crustose coralline algae discovered in American Samoa. *Coral Reefs*, **17**, 144.
71. Weil E, Croquer A, Flynn K, *et al.* 2014. Spatial and temporal dynamics of diseases affecting the sea-fan *Gorgonia ventalina* in La Parguera, southwest coast of Puerto Rico. 3rd. Asian-Pacific Coral Reef Symposium, abstract book, p. 211.