水生生物研究, 2013 年, 第 2 卷, 第 1-5 页
Shuisheng Shengwu Yanjiu, 2013, Vol.2, 1-5
http://biopublisher.cn/index.php/aor

研究简报

A Letter

由于沉积物-微生物的相互作用，波斯湾北部的滨珊瑚礁大量死亡率

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水生生物研究, 2013 年, 第 2 卷, 第 6 篇 doi: 10.5376/aor.cn.2013.02.0006

引用格式：

Kavousi et al., 2013, Mass Mortality of *Porites* Corals on Northern Persian Gulf Reefs due to Sediment-Microbial Interactions, Indonesia, International Journal of Marine Science, Vol.3, No.38 306-310 (doi: 10.5376/ijms.2013.03.0038)

摘 要 关于波斯湾珊瑚病的资料很少，然而近年来，特别是伊朗波斯湾方面报告的珊瑚疾病在增加。在这篇文章中，我们报道了白毡病导致的在霍尔木兹岛滨殖民地的群众死亡率。

关键词 滨珊瑚死亡率; 白毡病; 霍尔木兹岛; 伊朗

Mass Mortality of *Porites* Corals on Northern Persian Gulf Reefs due to Sediment-Microbial Interactions

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Abstract Little information is available on coral diseases in the Persian Gulf; however, in the recent years, reports of coral diseases increased in particular from Iranian side of the Persian Gulf. In this paper we report a White Mat Disease resulting in mass mortality of *Porites* colonies at Hormuz Island. This outbreak infected 96% of all *Porites* colonies and killed 58±30% (mean ± SD) of all *Porites* tissues.

Keywords *Porites* mortality; White mat disease; Hormuz Island; Iran

1 介绍

作为地球上最多样化的生态系统之一，世界上的珊瑚礁在过去十几年里受到了来自全球和当地的压力和威胁，导致了巨大的破坏(Burke et al., 2011; Fisher et al., 2011)。疾病为珊瑚礁全球性的退化做出了最重要的贡献(Goreau et al., 1998; Weil et al., 2006; Bruno et al., 2007; Rosenberg and Kushmaro, 2011)。几乎没有珊瑚病的类型信息，但是，它存在于印度洋中，包括波斯湾(Riegl and Purkis, 2012)。

波斯湾被认为是珊瑚礁中具有高温度波动的最极端的环境之一，从冬天的 12℃ (Sheppard et al., 1992) 到夏天的 38℃ (Baker et al., 2004)，高盐度(高达 39 pus)，高沉降速率，低深度(平均 35m, 大多数珊瑚礁深度<10m)，和低水循环，特别是在海湾南部(参考 Riegl and Purkis, 2012)。尽管是最能容忍的珊瑚礁之一(Burt et al., 2011)，波斯湾的珊瑚礁由于温度异常而遭遇大规模的珊瑚漂白事件(Coles and Riegl, 2012; Kavousi et al., unpublished data)。此外，波斯湾 85%的珊瑚礁被认为受到了当地局部压力的威胁(Burke et al., 2011)。另外根据报告，珊瑚病最近被认为是对波斯湾珊瑚的另一个严重威胁。

虽然在波斯湾进行的系统和定量研究很少(Riegl and Purkis, 2012)，但近年来，认识到和未特征化的珊瑚病的报告有所增加，特别是来自波斯湾北部的，其中包括拉腊克岛、克什姆岛和汉加姆岛(Samimi-Namin et al., 2010; Kavousi and Rezai, 2011)。在这篇文章中，我们报告了一种导致了波斯湾霍尔木兹岛大量珊瑚死亡的白毡病。

2 材料与方法

在 2012 年 8 月下旬和 9 月初对伊朗波斯湾进行实地调查期间，因大规模珊瑚白化，在霍尔木兹岛东部观察到了疾病的爆发(27° 03′ N, 56° 30′ E; 图 1)。为了估计珊瑚礁的底层覆盖，在小于 4m 而大多数珊瑚存在的地方建立了 10 米的截断线。通过随机计数 100 个珊瑚菌落获得感染的珊瑚菌落的数量，使用 Photoquadrat 的方法(n=70)来计算由于白色垫子引起的珊瑚组织死亡率。根据 Hill 和 Wilkinson (2004)提到

的方法，使用的方法是通过 10 天沉积物捕集器收集的累积沉积物来计算出该区域的沉降速率。将三个具有连接到每个杆(具有 9 个捕集器)的沉淀阱的三个杆锤击到珊瑚礁的三侧；但是，数据显示：因为其他三个陷阱的数据丢失，所以这里呈现的数据来自于 6 个陷阱。沉降速率以 gr/ cm^2 /天的方式记录。

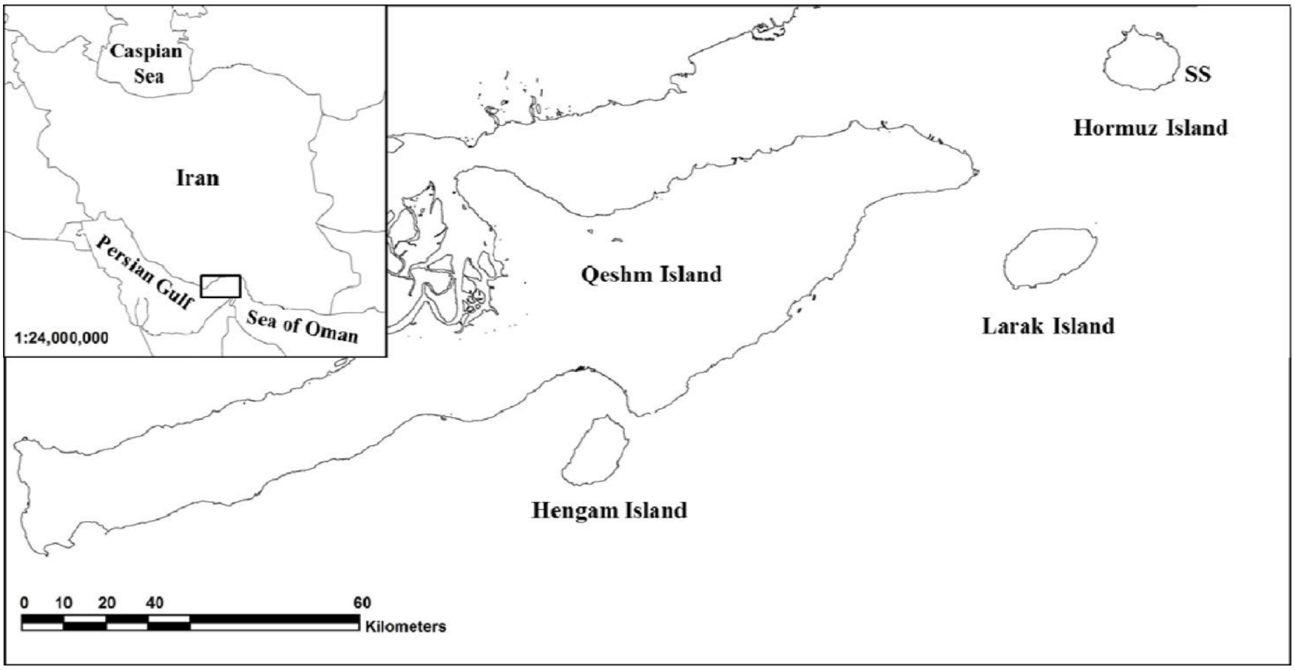

图 1 地图中的地区包括这项研究中审查的霍尔木兹岛。SS=本研究中研究的地点

Figure 1 Map of the area including Hormuz Island where was examined in this study. SS= studied site in this study

3 结果与讨论

霍尔木兹岛主要的珊瑚礁位于东部，2-4 米深，包括主要的造礁石，59.79±15.95% (平均值±SD)的珊瑚礁石和 8.68±7.01% (平均值±SD)的底层。这个地区主要是大量的滨珊瑚属(超过 85%的珊瑚礁)。高沉降速点是该位点的永久性特征(图 2 A)，并且测量出的速率是 0.052±0.014 gr/cm^2/天，珊瑚和其纽带在过去三年中显示健康(图 2 B, 个人观察)，然而，在 2012 年夏天，珊瑚礁滨珊瑚属突然出现珊瑚褪色(Kavousi et al., 未发表的数据)以及，随即而来爆发的疾病。

例如藻类(Goreau et al., 1998; Barott et al., 2012)和致病细菌(Kline and Vollmer, 2011)的原因导致珊瑚死亡率的侵入性生物的过度生长在全世界都是有普遍性的，但是来自硫酸盐还原细菌的质量珊瑚死亡是罕见的，这是在 2012 年夏天在波斯岛霍尔木兹岛的礁石珊瑚上记录的现象。

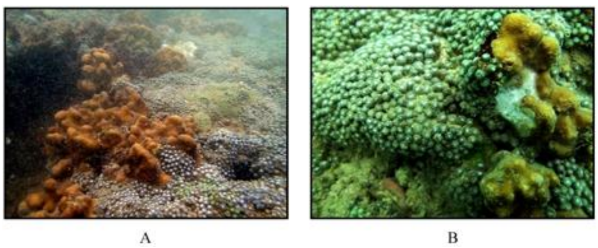

图 2 A: 由于霍尔木兹岛东部珊瑚礁周围的高沉降造成的浑水 B:沉积物沉积在活生物体作为该地点的永久特征，比如霍尔木兹岛上的珊瑚

Figure 2 A: Turbid waters due to high sedimentation around coral reefs at eastern Hormuz Island B: Deposition of sediments on live organisms such as corals and zoanthids as a permanent characteristic of this site

虽然所有的珊瑚菌落受热应力(从部分漂白到完全漂白)的影响，珊瑚受到白色垫细菌的影响发育过度了(图 3 A 和 B)，感染了所有滨珊瑚群体的 96%，并杀死了滨珊瑚组织的 58±30% (平均值 ±SD)。在霍尔木兹和拉拉克群岛的几个珊瑚属也观察到同样的现象。

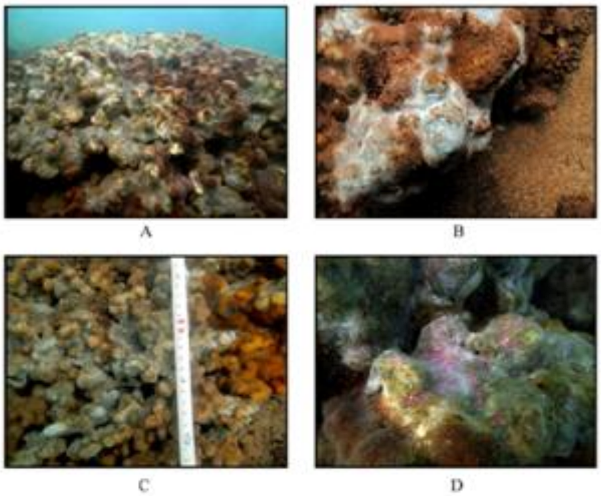

图 3 A: 由于细菌垫在霍尔木兹的滨珊瑚属菌落的质量死亡率 B: 滨珊瑚菌落上的白色垫细菌 C: 由于硫化铁沉淀，白色垫细菌覆盖黑色层 D: 光合硫和非硫细菌可能是桃红色和绿色

Figure 3 A: Mass mortality of *Porites* colonies at Hormuz Island due to bacterial mats B: White mat on a *Porites* colony C: White mats changed overlying black layers due to iron sulfide precipitation D: Photosynthetic sulfur and non-sulfur bacteria are probably responsible for pink and green colors

关于由于疾病造成的白化后珊瑚死亡的报告在全世界范围内增加(Bruno et al., 2007; Miller et al., 2009; Riegl et al., 2011; Bastidas et al., 2012)。虽然，有时候面临轻度和有时严重白化的珊瑚礁可以快速恢复(e.g. Goreau et al., 2000; West and Salm, 2003; Riegl et al., 2011)，但是疾病会大幅度降低几种珊瑚礁的抗逆性，并且在几年的时间里拼命抵抗(Goreau et al., 2000; Rosenberg and Loya, 2004; Sutherland et al., 2004)。

大量的滨珊瑚属被称为对热应力最耐受的珊瑚(Goreau et al., 2000; Loya et al., 2001)；然而，这个研究表明滨珊瑚属仍然容易受白化事件的次要影响，包括这次珊瑚疾病。此外，受珊瑚病影响的珊瑚礁具有较小的抗性和弹性，导致它有更多的可能性被侵入性生物和竞争对手影响到过度生长，比如大型藻类和其他珊瑚礁建设者；然而，即使在不可见的压力下，纽扣珊瑚依然可以生长超过珊瑚礁(Figure 4A, B, C; J. Kavousi, 个人观察)。霍尔木兹岛东部的珊瑚礁主要由纽扣珊瑚(59.79±15.95%)主导。虽然珊瑚礁受到最近的白化事件的影响，但是纽扣珊瑚没有显示白化或者疾病的现象。据报道称，由于气候的变化及其后果，从珊瑚为主的珊瑚礁在向非鳞翅目珊瑚礁珊瑚转变(reviewed by Norström et al., 2009; Bell et al., 2013)。这有可能导致霍尔木兹岛东部的珊瑚礁在当前气候变化下局部毁灭。

硫氧化细菌比如背日阿托氏菌落，丝硫细菌落和辨硫菌属等我认为是白色垫菌中的优势细菌(Jorgensen, 1977; Jorgensen and Postgate, 1982; Fenchel et al., 2012)。在第一次观察后不到 24 个小时,受影响组织的白色表现出现了暗色底层(图 3 C)，可能是由于硫化铁沉淀造成的。在大多数感染的珊瑚菌落上观察到的粉红色和绿色底层(图 3 D)可以是光合硫和非硫细菌；然而，还需要微生物检查。

虽然报道称硫氧化物细菌和珊瑚死亡率有关(Garrett and Ducklow, 1975; Mitchell and Chet, 1975)，但是以前的观察涉及非常局部的珊瑚死亡，这通常是由于实验室中的人为诱导应激与田间沉积物应力有关(Weber et al., 2012)。

硫氧化物细菌是可见的附生现象，其是死亡的结果，而不是原因。用细颗粒泥泞的珊瑚表面组织产生局部缺氧位点(Erftemeijer et al., 2012)，其由厌氧，异氧硫酸盐还原细菌定植。它们产生的硫化氢随后杀死珊瑚组织(Weber et al., 2006; 2012)。硫氧化物细菌存在于充气水和坏死组织之间的界面，并且从上方用氧气来氧化下方逸出的硫化氧。它们沉淀内部元素硫颗粒(Jorgensen, 1977; Fenchel et al., 2012)，它们给它们提供了独特的白色垫细菌外观(Richardson, 1998)。这个细菌垫倾向于在组织表面捕获(Miller and Richardson, 2012)和维持缺氧状况(Jorgensen and Postgate, 1982)，加快珊瑚死亡率。因此，该疾病是沉积物应力的二次微生物效应(Weber et al., 2012)，而不是直接攻击珊瑚组织的主要原体。在有沉积，尤其是有机负荷，温暖条件和弱水运动的条件下，影响最为严重。

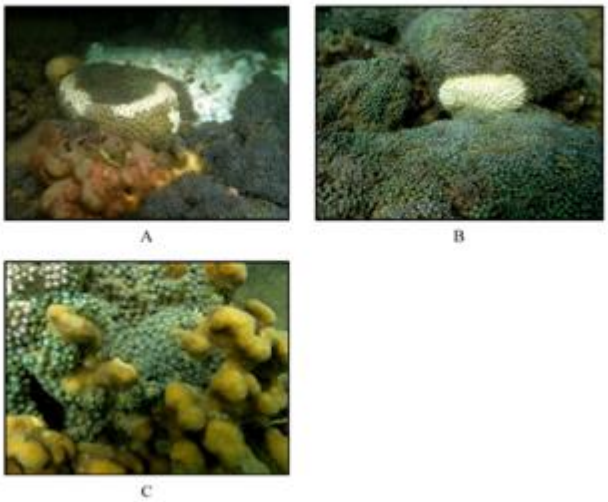

图 4 在霍尔木兹岛东部珊瑚礁的纽扣珊瑚的生长包括: A: 菊珊瑚属 B: 扁脑珊瑚属 C: 滨珊瑚属

Figure 4 Overgrowth of zoanthids on coral colonies including A: Favia B: Platygyra C: Porites at the east of Hormuz Island

近年来，波斯湾报告的珊瑚疾病数量和珊瑚疾病爆发的增加被评估为由于频繁的珊瑚疾病导致未来大规模死亡的迹象，可能导致珊瑚礁退化和珊瑚灭绝。因此，监测珊瑚疾病的长期影响以及在波斯湾进行组织学和微生物学检查是很有必要的。

致谢

我们感谢 T.J. Goreau 教授的专业意见来提高这篇稿件。英文编辑由 T. Goreau and T. McClelland 完成。

参考文献

Baker A.C., Starger C.J., McClanahan T.R., and Glynn P.W., 2004, Corals' adaptive response to climate change, Nature, 430: 741 http://dx.doi.org/10.1038/430741a

Bell J.J., Davy S.K., Jones T., Taylor M.W., and Webster N.S., 2013, Could some coral reefs become sponge reefs as our climate changes? Global Change Biology, doi: 10.111/gcb.12212
http://dx.doi.org/10.1111/gcb.12212

Bruno J.F., Selig E.R., Casey K.S., Page C.A., Willis B.L., Harvell C.D., Sweatman H., and Melendy A.M., 2007, Thermal stress and coral cover as drivers of coral disease outbreaks, PLoS Biology, 5: e124
http://dx.doi.org/10.1371/journal.pbio.0050124

Burke L.M., Reytar K., Spalding M., and Perry A., 2011, Reefs at risk revisited, World Resources Institute, Washington DC, USA

Burt J., Al-Harthi S., and Al-Cibahy A., 2011, Long-term impacts of coral bleaching events on the world's warmest reefs, Marine Environmental Research, 72: 225-229
http://dx.doi.org/10.1016/j.marenvres.2011.08.005

Coles S.L., and Riegl, B.M., 2012, Thermal tolerances of reef corals in the Gulf: A review of the potential for increasing coral survival and adaptation to climate change through assisted translocation, Marine pollution bulletin, 72: 323–332Erftemeijer P.L., Riegl B., Hoeksema B.W., Todd P.A., 2012, Environmental impacts of dredging and other sediment disturbances on corals: a review, Marine Pollution Bulletin, 64: 1737-1765

Fenchel T., Blackburn H., and King G.M., 2012, Bacterial biogeochemistry: The Ecophysiology of Mineral Cycling, Academic Press, pp. 312

Fisher R., Radford B.T., Knowlton N., Brainard R.E., Michaelis F.B., and Caley M.J., 2011, Global mismatch between research effort and conservation needs of tropical coral reefs, Conservation Letters, 4: 64-72
http://dx.doi.org/10.1111/j.1755-263X.2010.00146.x

Garrett P., and Ducklow H.W., 1975, Coral disease in Bermuda, Nature, 253: 349-350
http://dx.doi.org/10.1038/253349a0

Goreau T., McClanahan T., Hayes R., and Strong A., 2000, Conservation of coral reefs after the 1998 global bleaching event, Conservation Biology, 1: 5-15
http://dx.doi.org/10.1046/j.1523-1739.2000.00011.x

Goreau T.J., Cervino J., Goreau M., Hayes R., Hayes M., Richardson L., Smith G., DeMeyer K., Nagelkerken I., Garzon-Ferrera J., Gil D., Garrison G., Williams E.H., Bunkley-Williams L., Quirolo C., Patterson K., Porter J., and Porter K., 1998, Rapid spread of diseases in Caribbean coral reefs, Revista Biologia Tropical, 46 Supl. 5: 157-171

Hill J., and Wilkinson C., (eds.), 2004, Methods for ecological monitoring of coral reefs, Australian Institute of Marine Science, Townsville

Jorgensen B.B., 1977, Bacterial sulfate reduction within reduced microniches of oxidized marine sediments, Marine Biology, 41: 7-17
http://dx.doi.org/10.1007/BF00390576

Jorgensen B.B., and Postgate J.R., 1982, Ecology of the Bacteria of the Sulphur Cycle with Special Reference to Anoxic-Oxic Interface Environments [and Discussion], Philosophical Transactions of the Royal Society of London B, Biology Sciences, 298, 543-561 http://dx.doi.org/10.1098/rstb.1982.0096

Jorgensen B.B., and Postgate J.R., 1982, Ecology of the Bacteria of the Sulphur Cycle with Special Reference to Anoxic-Oxic Interface Environments [and Discussion], Philosophical Transactions of the Royal Society of London B, Biology Sciences, 298, 543-561

Kavousi J., and Rezai H., 2011, Coral lesions around some Iranian Islands in the Persian Gulf, Galaxea, 13: 5-6 http://dx.doi.org/10.3755/galaxea.13.5

Kline D.I., and Vollmer S.V., 2011, White Band Disease (type I) of endangered Caribbean acroporid corals is caused by pathogenic bacteria, Scientific Reports, 1:7
http://dx.doi.org/10.1038/srep00007

Loya Y., Sakai K., Yamazato K., Nakano Y., Sambali H., and van Woesik R., 2001, Coral bleaching: the winners and the losers, Ecology Letters, 4: 122-131 http://dx.doi.org/10.1046/j.1461-0248.2001.00203.x

Miller A.W., and Richardson L.L., 2012, Fine structure analysis of black band disease (BBD) infected coral and coral exposed to the BBD toxins microcystin and sulfide, Journal of Invertebrate Pathology, 109: 27-33
http://dx.doi.org/10.1016/j.jip.2011.09.007

Miller J., Muller E., Rogers C., Waara R., Atkinson A., Whelan K.R.T., Patterson M., and Witcher B., 2009, Coral disease following massive bleaching in 2005 causes 60% decline in coral cover on reefs in the US Virgin Islands, Coral Reefs, 28: 925-937
http://dx.doi.org/10.1007/s00338-009-0531-7

Mitchell R., and Chet I., 1975, Bacterial attck of corals in polluted seawater, Microbial Ecology, 2: 227-233
http://dx.doi.org/10.1007/BF02010442

Norström A.V., Nyström M., Lokrantz J., and Folke C., 2009, Alternative states on coral reefs: beyond coral-macroalgal phase shifts. Marine Ecology Progress Series, 376: 295-306
http://dx.doi.org/10.3354/meps07815

Richardson L.L., 1998, Coral diseases: what is really known, Trends in Ecology & Evolution, 13: 438-443
http://dx.doi.org/10.1016/S0169-5347(98)01460-8

Riegl B.M., Purkis S.J., Al-Cibahy A.S., Abdel-Moati M.A., and Hoegh-Guldberg O., 2011, Present limits to heat-adaptability in corals and population-level responses to climate extremes, PloS one, 6: e24802
http://dx.doi.org/10.1371/journal.pone.0024802

Riegl B.M., and Purkis S.J., eds., 2012, Coral Reefs of the Gulf, Springer, pp. 250
http://dx.doi.org/10.1007/978-94-007-3008-3

Rosenberg E., and Kushmaro A., 2011, Microbial diseases of corals: pathology and ecology, In: Dubinsky Z., Stambler N., (eds.), Coral Reefs: An Ecosystem in Transition, pp. 451-464
http://dx.doi.org/10.1007/978-94-007-0114-4_26

Rosenbreg E., and Loya Y., eds., 2004, Coral health and disease, Springer, pp. 488
http://dx.doi.org/10.1007/978-3-662-06414-6

Samimi-Namin K., Risk M.J., Hoeksema B.W., Zohari Z., and Rezai H., 2010, Coral mortality and serpulid infestations associated with red tide in the Persian Gulf, Coral Reefs, 29: 509
http://dx.doi.org/10.1007/s00338-010-0601-x

Sheppard C.R.C., Price P., and Roberts C., (eds.), 1992, Marine ecology of the Arabian Region, Academic Press, London, England

Sutherland K.P., Porter J.W., and Torres C., 2004, Disease and immunity in Caribbean and Indo-Pacific zooxanthellae corals. Marine Ecology Progress Series, 266: 273-302
http://dx.doi.org/10.3354/meps266273

Weber M., de Beer D., Lott C., Polerecky L., Kohls K., Abed R.M.M., Ferdelman T.G., and Fabricius K.E., 2012, Mechanisms of damage to corals exposed to sedimentation, PANS, 109: E1558-E1567
http://dx.doi.org/10.1073/pnas.1100715109

Weber M., Lott C., and Fabricius K.E., 2006, Sedimentation stress in a scleractinian coral exposed to terrestrial and marine sediments with contrasting physical, organic and geochemical properties, Journal of Experimental Marine Biology and Ecology, 336:18-32 http://dx.doi.org/10.1016/j.jembe.2006.04.007

Weil E., Smith G., and Gil-Agudelo D.L., 2006, Status and progress in coral reef disease research, Diseases of Aquatic Organisms, 69: 1-7 http://dx.doi.org/10.3354/dao069001

West J.M., and Salm R.V., 2003, Resistance and resilience to coral bleaching: implications for coral reef conservation and management, Conservation Biology, 17: 956-967
http://dx.doi.org/10.1046/j.1523-1739.2003.02055.x