# Zoonotic Fish Disease and Adaptive Fishery Management: Considerations for Striped Bass (*Morone saxatilis*) from the Chesapeake Bay

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*Abstract:* Mycobacteriosis is a widespread, chronic disease of estuarine fishes. Recent studies by scientists at the National Fish Health Research Laboratory, Leetown, West Virginia and the Virginia Institute of Marine Science, Gloucester, have shown infection rates in striped bass (*Morone saxatilis*) of up to nearly 62% in certain Virginia tributaries to Chesapeake Bay (Bay). Of the several mycobacterial species known to infect striped bass from the Bay, several are known to be zoonotic including *M. marinum* and *M. fortuitum*. In this paper we discuss the incidence and prevalence of mycobacterial infections in striped bass and contrast these with human epidemiological data on the occurrence of cutaneous mycobacteriosis in the Bay's human population collected by the Virginia Department of Health and the Maryland Department of Health. During a period from 1995–2005, the Commonwealth of Virginia (VA) and State of Maryland (MD) collectively documented 275 cases of non-tuberculosis mycobacteria (NTM) infections by *M. marinum* in the human population within the Bay watershed. The data indicates that most of the persons infected were males (67%-VA; 67%-MD) between the ages of 40 and 70 (79%-VA; 62%-MD) and that most infections occurred on fingers and hands (43%-VA 63%-MD). During the same 10-year period, only four cases of NTM infection were recorded in 11 non-Bay counties from both states combined. While cause-and-effect relationships cannot be clearly demonstrated between the epizootic of mycobacteriosis in striped bass and these elevated incidences of NTM cutaneous infections in the human population of the Bay counties, the weight-of-evidence suggests reason for concern. Based on these concerns, a workshop of federal, state and academic researchers and managers was convened in May 2006 in Annapolis, Maryland, to develop an adaptive management framework of both short-term and long-term resources management needs. These proposed research and management actions were predicated on understanding the etiology of the infectious disease and having effective communication networks in place for sharing information, making decisions, and sharing information among fishery managers, public health officials and veterinarians.

*Key words:* striped bass, mycobacteria, zoonotic disease

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl Agencies 60:140–144

Fish pathogens cause disease in many species of freshwater and marine fishes; however, relatively few fish pathogens are known to be zoonotic, that is, causing disease in humans. While the risk to humans of contracting infection from fish pathogens is generally low, an awareness of the potential risks is important for fishery managers, anglers, and commercial fishermen. One of these pathogen groups of increasing interest in the Chesapeake Bay Region are the mycobacteria, in particular, *Mycobacterium marinum*, one of the causative agents of mycobacteriosis in striped bass (Rhodes et al. 2001) and one of the causes of cutaneous mycobacteriosis in humans (Grant and Olsen 1999).

Mycobacteriosis is a widespread, chronic disease of estuarine fishes. Several *Mycobacterium* species have been identified from, and are known to affect, over 167 fish species worldwide (Rhodes et al. 2001). Recent studies by scientists at the National Fish Health Research Laboratory, Leetown, West Virginia and the Virginia Institute of Marine Science, Gloucester, have shown infection rates in striped bass (*Morone saxatilis*) of up to 62% in certain Virginia tributaries to Chesapeake Bay (Ottinger et al. 2005). Of the several mycobacteria species known to infect striped bass, several are known to be zoonotic including *M. marinum* and *M. fortuitum* (Elko et al. 2004). Previous studies have shown that careless handling of infected fish represents a potential health risk to anglers, commercial fishers, and fishery management workers and that the resulting localized skin lesions can be very difficult to treat. Immunocompromised individuals can be especially at risk of infection to several waterborne pathogens including *M. marinum* (Glaser et al. 1994). Rhodes et al. (2001) hypothesized that an epizootic of mycobacteriosis in Chesapeake Bay (Bay) striped bass may serve as a reservoir for transmission of mycobacterial infections to humans.

This paper discusses previously published findings regarding mycobacterial infections in striped bass from Chesapeake Bay and contrasts those findings to epidemiological data on the occurrence of human cutaneous mycobacteriosis in the Bay watershed collected by the Virginia Department of Health and the Maryland

Department of Health and Mental Hygiene. The data are then discussed within the context of developing adaptive management strategies that include fish and human health components.

## Methods

Surveillance for mycobacteria in Virginia is conducted by the Virginia Department of Health, Division of Disease Prevention, where epidemiological data collection is focused on the causative agent of tuberculosis in humans, *Mycobacterium tuberculosis*. Other mycobacteria, or non-tuberculous mycobacteria (NTM), including bacteria in the *Mycobacterium avium* complex, *M. ulcerans*, *M. haemophilium*, *M. marinum*, or any unidentified *Mycobacterium* are also reported from diagnostic laboratories. However, minimal information is collected since *M. marinum* and other NTMs are not reportable diseases within the Commonwealth of Virginia. Notwithstanding these limitations, we were able to compile some reported cases of *M. marinum* for the years 2000–2005 from 30 counties within the Bay watershed of Virginia (Fig. 1). Similar epidemiological data were also available from the Maryland Department of Health and Mental Hygiene. In the State of Maryland, NTMs are a reportable disease and included in confidential morbidity reports filed by laboratories and other diagnosticians. In these instances, the Division of Medical Microbiology provided a summary of laboratory reports from clinical specimens, sorted by the 16 counties bordering Chesapeake Bay from 1995–2005 (Fig. 1). Data from both states included year of birth or age, sex of the patient, and the nature of the infection (e.g., finger, hand, or foot, etc.). No data were available regarding the mechanisms of injury/infection or the patient's occupation.

In order to contrast the incidences of human cutaneous my-

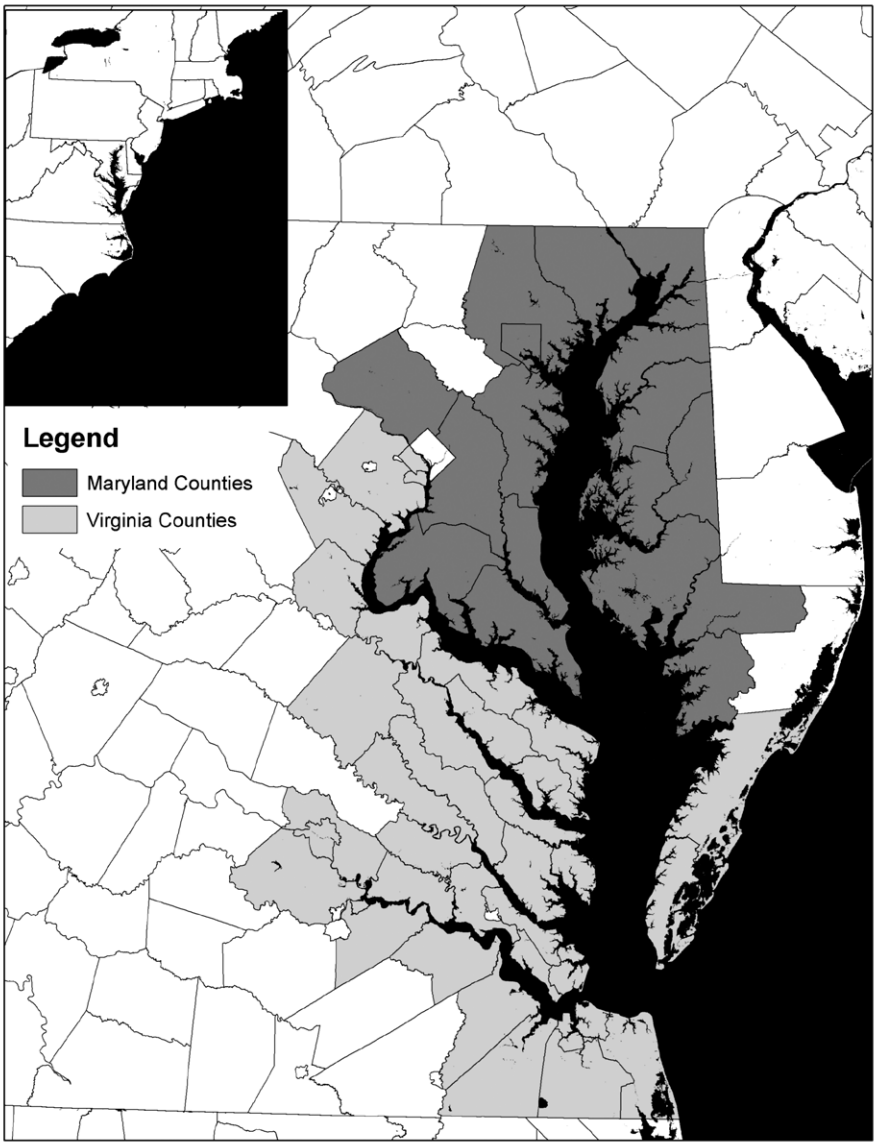


**Figure 1.** Map of Chesapeake Bay showing counties in Maryland and Virginia surveyed for nontuberculous human infections of *Mycobacterium marinum,* 1995–2005.

cobacteriosis cases in Bay counties to the general population, we compiled similar data from counties outside of the Chesapeake Bay within both states. In Virginia, we examined the database of reportable communicable diseases from the Central Shenandoah (5 counties) and Central Virginia (4 counties) Districts, from 2000–2005. In Maryland, we examined records from Allegheny and Garrett counties in the western most reaches of the state. In all instances, the case numbers reported were raw data not corrected for population size.

## Results

During a period from 1995–2005, the Commonwealth of Virginia and State of Maryland collectively documented 275 cases of NTM infection by *M. marinum* in the human population within the Bay watershed (Fig. 2). In Maryland, data were available from confidential morbidity reports provided by the Department of Health and Mental Hygiene, Office of Epidemiology and Disease Control Programs (Dr. John P. Krick, personal communication). A total of 191 case reports were available for the 10-year period. Case reports were obtained from seven Bay counties with the majority of cases obtained from Ann Arundel ($N$ = 106) and Talbot ($N$ = 51) counties. In Virginia, the Department of Health, Division of Disease Prevention reported 84 cases of human cutaneous mycobacterial infection from 2000–2005. The majority of these cases originated in the Rappahannock ($N$ = 10), Peninsula ($N$ = 8), and Three Rivers ($N$ = 8) reporting Districts along the tidewater areas of Chesapeake Bay. When the data for both states were combined and sorted by reporting month, the trend shows a general increase in the number of cases during the fall and winter with the lowest reported number of cases occurring in the spring (Fig. 3).

There was limited demographic information associated with case reports from both states. From the data provided we determined that most of those infected persons were males (67%-VA; 67%-MD) between the ages of 40 and 70 (79%-VA; 62%-MD). Most infections were on fingers and hands (43%-VA 63%-MD), but were also noted from other skin surfaces on knees, legs, and feet (Fig. 4). A portion of the reports provided no information on the location or degree of infection (36% -VA; 27%-MD).

No demographic data were available on the mechanisms of injury or infection or the occupation of the patient. Therefore, we have no means of linking incidences of infection with recreational or commercial fishing or other secondary contact with Bay waters. However, during the same 10-year period, only four cases of NTM infection were recorded in non-Bay counties in Virginia. No NTM infections were reported from the two non-Bay counties in Maryland.

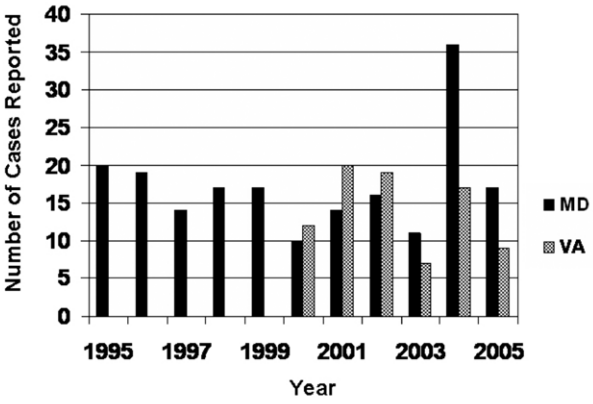


**Figure 2.** Number of reported human cases of cutaneous mycobacteriosis in Maryland and Virginia, 1995–2005.

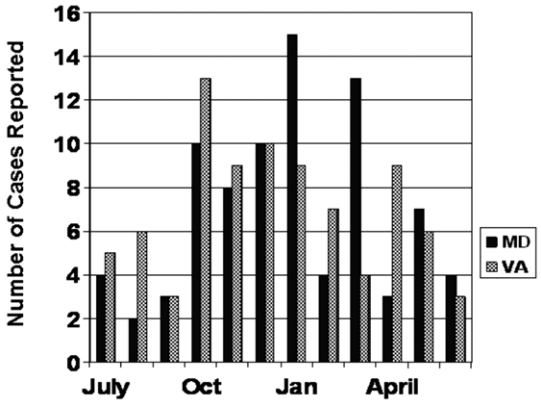


**Figure 3.** Number of cutaneous mycobacteriosis cases received by month in Maryland and Virginia counties within the Chesapeake Watershed for all years combined (2000–2005).

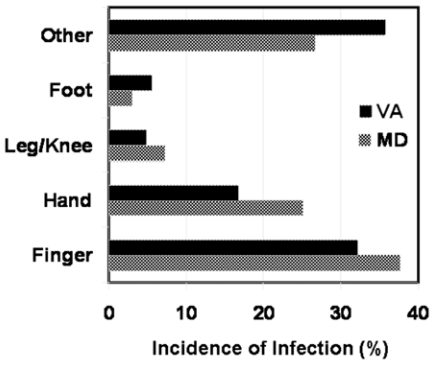


**Figure 4.** Cutaneous mycobacteria infections in the human population of the Chesapeake Bay Region, 1995–2005.

## Discussion

Striped bass are an important commercial and recreational species along the Atlantic coast from Maine to North Carolina. Recreational angling alone brings an estimated US$1 billion dollars to local economies along the Atlantic coast and up to $470 million in the Maryland and Virginia fisheries (Southwick Associates 2005). Having suffered from precipitous population declines in Chesapeake Bay in the 1980s, a joint federal-state initiative to restore this important species culminated in 1995 with a declaration of success (Richards and Rago 1999). Fish stocks that had crashed in the 1980s were restored to historical levels of recreational and commercial harvest. Along with this population increase, significant increases in natural mortality among the Maryland Chesapeake Bay spring spawning stock have been noted (Atlantic States Marine Fisheries Commission 2005). This has been most pronounced from 2000–2004 when the instantaneous natural mortality coefficient (M) ranged from 0.38 to 0.47 (Fig. 5). The cause(s) of this increased natural mortality are unknown. However, managers and researchers have observed that these increases in mortality are concurrent with increases in prevalence and occurrence of mycobacteriosis in striped bass populations within the Bay and its tributaries (Kahn and Crecco 2006). It is not known whether or not the two conditions are related.

Despite this uncertainty, a large portion of the adult striped bass in Chesapeake Bay are infected with mycobacteria (Ottinger et al. 2005) and mycobacteriosis has been shown to affect large numbers of striped bass in the Bay (7%-28% with external lesions; 21%-62% with internal lesions). In recent studies, Rhodes et al. (2004) isolated mycobacteria from 76% of the spleens harvested from 196 Chesapeake Bay striped bass. These high incidences of infection in fish populations subject to both recreational and commercial exploitation are cause for concern from a public health and fishery management perspective.

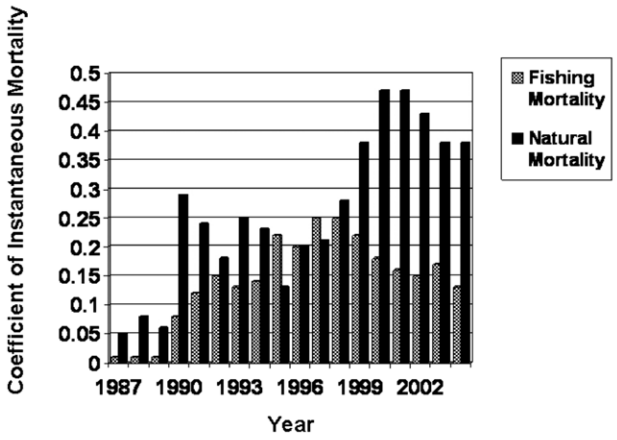


**Figure 5.** Coefficients of instantaneous fishing and natural mortality in Maryland Chesapeake Bay spring spawning stock of striped bass (data from Atlantic States Marine Fisheries Commission 2005).

*Mycobacterium marinum* causes an opportunistic skin and soft tissue infection in humans known as fish-handler's disease or fish-tank granuloma. Most often the infection is due to inoculation by puncture wounds or through open sores, cuts, and/or abrasions in the skin (Blackwell and Yu 2001). It is most common in individuals with occupations that require handling large numbers of fish such as commercial fisherman and aquaculture and restaurant workers. The incubation period for the disease varies from 4–8 weeks and most typically occurs on fingers and hands although any skin surface is vulnerable. The infection usually results in small lesions that exhibit swelling and tenderness. There could also be some discharge from areas that become necrotic. Without treatment, immunocompetent individuals will completely heal in 1–2 years (Dobos el al. 1999). Puncture wounds to hands and fingers from fish spines can result in arthritis and tenosynovitis of the hand and wrist (Blackwell and Yu 2001). Invasive infections are most often treated with antimycobacterial medications such as rifampin and ethambutol (Lahey 2003). Immunocompromised individuals with disseminated lesions may develop systemic infections with visceral involvement (Blackwell and Yu 2001). Once invasive disease is diagnosed, the average length of treatment with antimycobacterials is about 11.4 months (Lahey 2003).

The number of cases of human (NTM) infection by *M. marinum* in the Bay counties of Maryland and Virginia summarized in this study represents a significant increase from earlier investigations regarding *M. marinum* infections. A survey involving 46 laboratory centers from 33 states and the District of Columbia in 1981–1983 documented a national average of about 40 cases per year in all of the United States (O'Brien et al. 1987). A similar laboratory-based survey initiated in 1993 documented an annual national average incidence of 158 cases per year in the United States with most of these reported in the southeast (Dobos et al. 1999). Our data shows that over the past five years, the Commonwealth of Virginia and State of Maryland collectively averaged 31 cases per year in Bay counties. During the same time period only four cases were documented from inland, non-Bay counties. While we are unable to demonstrate any cause-and-effect relationships between the epizootic of mycobacteriosis in striped bass and these elevated incidences of NTM cutaneous infections in the human population of the Bay counties, the weight-of-evidence suggests reason for concern for both fishery and public health management. We are particularly interested in the increased incidence of human infection in the late fall and winter (Fig. 3) which coincides with an active period of recreational and commercial harvest of striped bass.

Knowledge of fish disease processes, fish disease defense mechanisms, and ecology is important to the development of fishery management strategies. This is especially true in large, complex ecosystems such as the Chesapeake Bay where epizootic or chronic disease affect fish at the population level. To achieve management objectives, managers should consider adaptive management techniques that incorporate aquatic animal health concerns whenever disease is implicated as a factor (Wilhere 2002). When zoonotic risks exist such as those for striped bass in Chesapeake Bay, this process should involve not only aquatic animal health specialists but also those responsible for public health decisions.

To address these evolving concerns for the health of striped bass in the Bay, the U.S. Geological Survey (USGS), National Fish Health Research Laboratory, partnered with National Oceanographic and Atmospheric Administration/National Ocean Service (NOAA/NOS) Cooperative Oxford Laboratory to sponsor a workshop on mycobacteriosis in Chesapeake Bay striped bass in May 2006. This workshop involved the principal federal and state agencies and academic research institutions involved with striped bass in the Bay (Ottinger and Jacobs 2006). The goals of the workshop were to establish the state of knowledge, develop a prioritized research agenda, and identify mechanisms by which research efforts could be optimized. The workshop was attended by 40 representatives from state and federal agencies, and academic institutions or research foundations. The workshop yielded a specific agenda of research and management actions for consideration by the involved agencies as first steps towards development of an adaptive management framework of both short-term and long-term resources management needs (Ottinger and Jacobs 2006). The development of this strategic framework was predicated on an understanding of the etiology of the infectious disease and having effective communication networks in place for sharing information, making decisions, and sharing information among fishery managers, public health officials and veterinarians. In addition to specific research priorities, the adaptive framework identified overarching themes for development of standardized approaches and unified databases for use in research and management. It also highlighted the need to develop public outreach programs, to monitor the economic impacts of disease in striped bass and to ensure human health and food safety (Ottinger and Jacobs 2006).

## Literature Cited


Atlantic States Marine Fisheries Commission. 2005. 2005 stock assessment report for Atlantic striped bass: Catch-at-age based VPA and tag release/recovery based survival estimation. Atlantic States Marine Fisheries Commission, November 2005.

Blackwell, V. and R. Yu. 2001. *Mycobacterium marinum* infections. Hong Kong Practitioner. 23: 107–110.

Dobos, K. M., F. D. Quinn, D. A. Ashford, C. R. Horsburgh, and C. H. King. 1999. Emergence of a unique group of necrotizing mycobacterial diseases. Emerging Infectious Diseases 5(3): 367–378.

Elko, L. E., K. Rosenbach, and J. Sinnott. 2004. Cutaneous manifestations of waterbourne infections. Current Infectious Disease Reports 5: 398–406.

Glazer, C. A., F. J. Angulo, and J. A. Rooney. 1994. Animal associated opportunistic infections among persons infected with the human immunodeficiency virus. Clinical Infectious Disease 18: 14–24.

Grant, S. and C. W. Olsen. 1999. Preventing zoonotic diseases in immunocompromised persons: The role of physicians and veterinarians. Emerging Infectious Diseases 5: 159–163.

Kahn, D. M. and V. Crecco. 2006. Tag-recapture data from Chesapeake Bay striped bass indicate that natural mortality has increased. *In*: USGS/NOAA Workshop on Striped Bass, 7–10 May 2006, Annapolis, Maryland. Pages 35–36 *In:* C. A. Ottinger and J. Jacobs, editors. USGS, Scientific Investigations Report 2006–5214, Reston, Virginia.

Lahey, T. 2003. Invasive *Mycobacterium marinum* infections. Emerging Infectious Diseases. 9(11): 1496–1498.

O'Brien, R. J., L. J. Geiter, and D. E. Snider.1987. The epidemiology of nontuberculous mycobacterial disease in the United States. American Review of Respiratory Disease. 135: 1007–1014.

Ottinger, C. A., V. S. Blazer, C. L. Densmore, D. T.Gauthier, H. Kator, F. M. Panek, M. W. Rhodes, and W. Vogelbein. 2005. Mycobacteriosis in Chesapeake Bay Striped Bass (*Morone saxatilis*). Pages 238–243 *in*: R. C. Cipriano, I. S. Shchelkunov and M. Faisal, editors. Health and diseases of aquatic organisms: Bilateral perspectives. Michigan State University Press. East Lansing.

———. and J. Jacobs., editors. 2006. USGS/NOAA Workshop on Striped Bass, 7–10 May 2006, Annapolis, Maryland. USGS, Scientific Investigations Report 2006–5214, Reston, Virginia.

Rhodes, M. W., H. Kator, S. Kotob, P. van Berkum, I. Kaatari, W. Vogelbein, M. M. Floyd, W. R. Butler, F. D. Quinn, C. Ottinger, and E. Shotts. 2001. A unique *Mycobacterium* species isolated from an epizootic of striped bass (*Morone saxatilis*). Emerging Infectious Diseases 7(5): 896–899.

———, ———, I. Kaattari, D. Gauthier, W. Vogelbein, and C.A. Ottinger. 2004. Isolation and characterization of mycobacteria from striped bass *Morone saxatilis* from the Chesapeake Bay. Diseases of Aquatic Organisms 61: 41–51.

Richards, R. A. and P. L. Rago. 1999. A case history of effective fishery management: Chesapeake Bay striped bass. North American Journal of Fisheries Management. 19:356–375.

Southwick Associates. 2005. The economics of recreational and commercial striped bass fishing: The Southwick Report. Stripers Forever, Inc.

Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. Conservation Biology 16(1): 20–29.