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Etiologies, observations and reporting of estuarine finfish lesions

A.S. Kane [a,*], M.J. Dykstra [b], E.J. Noga [b], R. Reimschuessel [c], A. Baya [d], C. Driscoll [e], H.W. Paerl [f], J. Landsberg [g]

[a]*Department of Veterinary Medicine, Aquatic Pathobiology Center, University of Maryland, 8075 Greenmead Drive, College Park, MD 20742, USA*
[b]*College of Veterinary Medicine, North Carolina State University, 4700 Hillsborough Street, Raleigh, NC 27606, USA*
[c]*Center for Veterinary Medicine, Office of Research, US Food and Drug Administration, 8401 Muirkirk Road, Laurel, MD 20708, USA*
[d]*Virginia-Maryland Regional College of Veterinary Medicine, University of Maryland, 8077 Greenmead Drive, College Park, MD 20740, USA*
[e]*Maryland Department of Natural Resources, Sarbanes Cooperative Oxford Laboratory, Oxford, MD 21654, USA*
[f]*Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, NC 28557, USA*
[g]*Florida Department of Environmental Protection, Florida Marine Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL 33701, USA*

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Abstract

Lesions in estuarine finfish are associated with a variety of organisms including parasites and bacterial, viral, and fungal infectious agents. In addition, trauma, suboptimal water quality, and other abiotic stress factors may result in the loss of homeostasis. We have observed solitary ulcerative lesions on menhaden sampled from the Chesapeake Bay, Maryland, the Pamlico River, North Carolina, and the St. Johns River, Florida. Histologically, the lesions demonstrated a marked chronic inflammatory infiltrate and granulomas in response to fungal hyphae throughout large areas of exposed necrotic muscle. Gram-negative rod-shaped bacteria were also observed in the lesions, a common finding in ulcers of aquatic organisms.

* Corresponding author. Tel.: +1-301-935-6083; fax: +1-301-935-6079.
E-mail addresses: akane@umaryland.edu (A.S. Kane), michael_dykstra@ncsu.edu (M.J. Dykstra), ed_noga@ncsu.edu (E.J. Noga), rreimsch@bangate.fda.gov (R. Reimschuessel), ambaya@wam.umd.edu (A. Baya), cdriscoll@dnr.state.md.us (C. Driscoll), hpaerl@email.unc.edu (H.W. Paerl), landsberg_j@epic7.dep.state.fl.us (J. Landsberg).

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Similar observations in menhaden and other species have been described previously in the literature as ulcerative mycosis, mycotic granulomatosis, red spot disease, and epizootic ulcerative syndrome. Despite the many different known causes of fish lesions, the popular press and the scientific literature have recently emphasized *Pfiesteria piscicida* and other *Pfiesteria*-like dinoflagellates (and their bioactive compounds) as the primary causative agent for finfish lesions, particularly mycotic granulomatous ulcers in Atlantic menhaden. While some laboratory data suggest that *Pfiesteria* may play a role in field-observed lesions, much more cause-and-effect evidence is needed to determine the importance of other risk factors, both alone or and in combination with *Pfiesteria*. In order to better understand the etiology of lesion initiation and progression in estuarine finfish, accurate assessments of environmental conditions collected on appropriate temporal and spatial scales, and fish morphological indicators consistent with gross and histological pathologic terminology, should be used for reporting fish lesion observations and kills. Further, this outlook will help to avoid bias and may foster a broader perspective for examining the health of estuarine systems in general.

Keywords: Fish pathology; Ulcers; Lesions; *Pfiesteria*; HABs

Long-term aquatic monitoring studies indicate elevated levels of anthropogenic nutrient loading, with hypoxia and anoxia increasing in frequency and magnitude in nutrient-enriched waters worldwide (Paerl, 1998). Further, anthropogenic discharges into aquatic systems include a broad spectrum of chemicals such as pesticides, herbicides, chlorinated hydrocarbons, polychlorinated biphenyls, hormone-like compounds, antibiotics, synthetic detergents and catalysts, and heavy metals. The dynamics of bacterial, fungal, and microalgal communities are likely affected by contamination and the increased rate of eutrophication in coastal waters (Paerl, 1998). The dynamics of fish parasitism may also be affected by contaminants and nutrient loading.

Increased nutrient and contaminant loading has been well documented in mid-Atlantic estuaries of the United States and is associated with increases in the incidence of fish disease (Noga, 1988). These anthropogenic stressors may directly exert toxicity to fish or aquatic animals or they may indirectly alter aquatic animal homeostasis and health. For example, increased nutrient loading, altered salinity gradients or changes in dissolved and suspended solids, may lead to depressed dissolved oxygen levels and altered buffering capacity. In turn, secondary effects such as increased numbers and virulence of microorganisms may then lead to disease in fish. Further, the increased incidence of harmful algal blooms, some of which are directly or indirectly in response to increased nutrient inputs, may also trigger fish disease and mortality events (Landsberg, 1995).

Ulcerative lesions and mortalities in finfish along the US Atlantic coast have been topics of renewed interest due, in large part, to recent harmful algal blooms (HABs) of toxic microorganisms including dinoflagellates such as *Pfiesteria piscicida*. Although over 25 species of fish are reported to be affected by *Pfiesteria*-like organisms, Atlantic menhaden appear most susceptible (Burkholder, Glasgow &

Hobbs, 1995). Reports of exposure effects in fish correlated with the presence of *Pfiesteria*-like organisms in low salinity waters include alteration of skin color, behavioral excitability, disorientation and inability to maintain position in the water column, the presence of skin lesions, and mortality (Burkholder, Noga, Hobbs & Glasgow, 1992; Burkholder et al., 1995).

Grossly, the skin lesions observed on Atlantic menhaden (collected during blooms of *Pfiesteria* and *Pfiesteria*-like dinoflagellates) are typically solitary and range from areas of redness to raised friable masses to penetrating ulcers affecting the dermis, underlying muscle and sometimes exposing viscera (Kane, Oldach & Reimschuessel, 1998). We also have noted a small number of field-sampled fish which appear to have healed lesions, indicating some ability of menhaden to recover from insults. Histologically, the ulcerative lesions, termed ulcerative mycosis, are typically characterized by a marked chronic inflammatory infiltrate and granulomas in response to fungal hyphae throughout large areas of exposed tissue (Kane et al., 1998; Noga & Dykstra, 1986). The fungus-like elements historically involved with these lesions are hyphae of the Oomycete, *Aphanomyces*. Gram-negative rod-shaped bacteria are also observed in the lesions, a common finding in ulcers of aquatic organisms.

There is a striking resemblance between the aforementioned ulcerative mycosis and reports of other epidemic ulcerative diseases seen in waters from around the world including mycotic granulomatosis, red spot disease, and epizootic ulcerative syndrome (Lilley, Callinan, Chinabut, Kanchanakhan, MacRae & Phillips, 1998). These similarities suggest that closer examination of environmental factors that may predispose fish to opportunistic infections is warranted. For example, lowered salinity due to rainfall events (Callinan, Paclibare, Bondad-Reantaso, Chin & Gogolewski 1995; Virgona, 1992) and excess water discharges (as seen in the St. Lucie River, Florida; J. Landsberg, unpublished data) appear to play a role in the subsequent appearance of lesions in fish. Difficulties in fulfilling Koch's postulates (i.e. laboratory re-infection and re-isolation studies) with *Pfiesteria*-like organisms or *Aphanomyces* strongly suggests that other risk factors in disease development are still unknown (Noga, 1998). This is not to suggest that HABs do not play a critical role in the initiation or progression of ulcerative finfish disease. In fact, at least 39 species of algae are associated with toxicoses in fish (Noga, 1998), and several more species have recently been implicated in fish mortality or disease events (Steidinger, Landsberg, Truby & Roberts, 1998). However, the involvement of HABs or HAB toxins as predisposing or initiating agents, or as immunosuppressants remains unclear. It is also important to recognize that many HABs have associated bacterial populations that, in turn, may act as vectors for fish disease, especially when fish are concurrently exposed to algal toxins.

In order to properly assess predisposition factors and causative agents of ulcerative skin lesions in fish, an epidemiological approach must be integrated into standardized ecological monitoring. A notable increase in effort has been recently mobilized by various state agencies to focus on monitoring fish health, lesion incidence, and various water quality parameters. For example, Gulf of Mexico Mortality Monitoring Network (GMNET; http://pelican.gmpo.gov/gmnet) has taken the lead to summon a consortia of management agencies in multiple states (Florida, Louisiana, Texas, Alabama, Georgia) in order to provide field monitoring and fish kill response consistency, as well as the sharing of datasets. The Sarbanes Cooperative Oxford Laboratory (Maryland Department of Natural Resource/NOAA) in conjunction with the University of Maryland Aquatic Pathobiology Center and the Virginia-Maryland Regional College of Veterinary Medicine (University of Maryland Campus), have developed intra- and interstate training for standardized field sampling and data collection techniques. These types of effort are essential to develop and support regional, if not global, integrated databases on fish health.

The need for consistency and consolidation of fish health data across state boundaries is demonstrated by the coastal and global nature of declines in the biological integrity of aquatic ecosystems (Epstein, Sherman, Spanger-Siegfried, Langston, Prasad & Mckay, 1998) and the association between increases in contaminant loading, habitat alteration, and fish disease incidence (Epstein et al., 1998; Sinderman, 1996). A report from the Health Ecological and Economic Dimensions (HEED) of Global Change Program (Epstein et al., 1998) supports the use of alterations in aquatic animal health (i.e. diseases) and the occurrence of HABs as biological indicators of the health of coastal environments. The HEED findings are based on a rise in the total disease incidence of aquatic organisms and the emergence of new diseases. For example, approaching the epizootiology of neoplasia by investigating the distribution of tumors in shellfish in relation to the distribution of HABs recently opened up possibilities of a previously uninvestigated causal relationship (Landsberg, 1996). Further, declining aquatic animal health poses human health risk regarding seafood consumption and recreation as well as economic losses for seafood industries, fishing communities, trade, travel, and tourism.

Fish skin lesions are easy to observe and are common manifestations of disease and environmental stress, although they do not represent a true assessment of complete fish health. In order to report fish skin lesion observations and develop utilitarian datasets for epidemiologic evaluation, we support the use of standardized protocols that provide ease of use and consistency. External lesions should be described to include size, number, location (head, trunk, vent, fins, etc.), type (loss of scales, area of redness, ulcer, etc.), shape (round, oval, irregular), texture (smooth, granular, nodular, cheesy), color and opacity, firmness (soft, hard), dimensionality (depressed, flat, raised), severity (minimal, mild, moderate, marked, severe), and extent (coverage; focal, multifocal, diffuse). Graphical illustrations of some of these descriptors have been posted on the World Wide Web to help exemplify these concepts (http://aquaticpath.umd.edu). More elaborate observation paradigms may also be used, as well as the use of histological classification schemes (Reimschuessel, Bennett & Lipsky, 1992). Regardless, basic terminology should be used to provide consistent datasets between agencies and states. Ultimately, an inter-regional database providing data entry and access ability by various management agencies and academic institutions will support a greatly needed epidemiological component to existing fish health monitoring programs. Such a database will serve as a valuable tool to better understand lesion etiologies and factors involved with lesion initiation and progression. An inter-regional database will also help managers and researchers to use similar language to describe field and laboratory observations, and will ultimately help to avoid bias and foster a broader perspective on examining not only fish health, but the health of estuarine systems in general.

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