Journal of Invertebrate Pathology 110 (2012) 211–224

Contents lists available at SciVerse ScienceDirect

Journal of Invertebrate Pathology

journal homepage: www.elsevier.com/locate/jip

Minireview

The impact of pathogens on exploited populations of decapod crustaceans

Jeffrey D. Shields *

Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062, USA

ARTICLE INFO

Article history:
Available online 14 March 2012

Keywords:
Lobster
Crab
Fishery
Fisheries
Disease
Outbreak
Epidemic

ABSTRACT

Several crustacean fisheries have experienced significant outbreaks of disease that have damaged their industries. Not only do fisheries suffer from direct losses to pathogens, such as disease-induced mortalities or reduced product value, but they can also incur indirect losses such as stunting, castration, and increased risk of predation. In some cases, the indirect losses can be substantial, yet they are often overlooked by the fishing industry as their primary focus is on recruits to the fishery, and not on the affected juvenile pre-recruits. Low levels of pathogens are to be expected in natural populations of commercial species, but baseline data on the prevalence and intensity of even the most common agents is often lacking. It is important to establish baselines for two reasons. First, it is important to know what pathogens exist in heavily exploited populations so as to gauge their potential to damage the industry; and second, during outbreaks, it is important to know whether an outbreak is a newly emergent event or whether it is a component of a cyclical phenomenon. Pathogens frequently act in concert with environmental stressors, and a variety of stressors have contributed to outbreaks of emerging agents in crustacean fisheries. Pollution, poor water quality, hypoxia, temperature extremes, and overexploitation have all been implicated as stressors in various outbreaks. This review focuses on epidemic diseases of commercially fished crustaceans. Outbreaks in cultured stocks are not covered. Disease epizootics have occurred in fished populations of crayfish and shrimp but they are less well known than the issues arising from extensive aquaculture of these species.

Contents

1. Introduction

Crustacean fisheries suffer direct and indirect losses to several pathogens. Direct losses are mortalities induced by pathogens, but they can be difficult to estimate. Nonetheless, mortalities can be widespread, causing extensive damage to impacted fishing communities. For example, the lobster mortality in Long Island Sound, 1999, devastated the industry in western Long Island Sound (Pearce and Balcom, 2005). That fishery sustained significant long-term damage due to the extent of the mortality. In addition, some pathogens can result in a direct loss of individuals by causing the

* Fax: +1 804 684 7186.
E-mail address: jeff@vims.edu

0022-2011/$ - see front matter
http://dx.doi.org/10.1016/j.jip.2012.03.011

formation of unappealing lesions rendering the crab or lobster unmarketable. Such animals cannot be marketed whole; hence, there is a loss in value for downgraded product. For example, clawed lobsters with epizootic shell disease are either culled or processed into the lower-valued canned meat industry. Unesthetically appealing seafood can impact public opinion, which happened to the finfish industry during the *Pfiesteria* scare in 1997–1998, when fish thought to contain presumptive toxins depressed the seafood industry (Magnien, 2001). The resulting hysteria threatened the commercial fishing industry of Chesapeake Bay because consumers were reluctant to purchase fish from the region. Most fishermen and their agents strive to sell a quality product so damage to public opinion can be difficult to repair.

Direct losses from pathogens can also impact unfished segments of the population, typically the juvenile or female subpopulations. Outbreaks in juveniles arguably cause more damage to fisheries because early life history stages are more sensitive or susceptible to pathogens and environmental stressors. Disease-related mortalities in juveniles have been documented in at least three important fisheries that include the blue crab (*Callinectes sapidus*), the snow crab (*Chionoecetes opilio*, *Chionoecetes bairdi*), and the Caribbean spiny lobster (*Panulirus argus*) (e.g., Messick and Shields, 2000; Shields and Behringer, 2004; Shields et al., 2005).

Indirect losses to pathogens can be difficult to assess because they are cryptic and require ongoing estimation techniques to census populations. However, stunting, castration, and morbidity leading to increased predation risk are outcomes associated with several pathogens of crustaceans. In some cases, the indirect losses can be substantial, yet they are often overlooked by the fishing industry because their primary focus is on recruits to the fishery, and not on the affected juvenile pre-recruits. For example, indirect effects can result from widespread egg mortality which in turn may limit larval supply (e.g., Wickham, 1986; Brattey et al., 1985), but this relationship can be difficult to establish at the population level. Nonetheless, mathematical models indicate that parasitic castrators can potentially regulate impacted crustacean populations (Blower and Roughgarden, 1989a,b). Given that several commercially important crab species harbor parasitic castrators (rhizocephalan barnacles, bopyrid isopods) and egg predators (nemerteans and amphipods), there is some validity to the larger impact caused by pathogens which cause indirect effects on their host populations.

As is often the case in crustacean diseases, the causative agent in an outbreak is rarely known or unreported until the onset of the initial epizootic. By definition, an outbreak is the occurrence of a pathogen at greater than baseline levels in a host population (Center for Disease Control and Prevention, 2007); thus it is important to know the baseline before one can ascertain the scale or effect of an outbreak. Baseline surveys are critical but often lacking. They can indicate the presence of a pathogen and give clues as to whether it has the potential to damage a fishery. Moreover, baselines can indicate whether an outbreak is a newly emergent event or whether it is a regular feature in the host population. If a pathogen is an emergent phenomenon, then the underlying (proximate) causes can be examined in more detail.

The scope of this review is to examine how outbreaks of parasites and diseases have impacted several crustacean fisheries. The primary focus will be on marine species because data and reporting systems are in place due to the use of logbooks and monitoring efforts of resource agencies. I have not provided an exhaustive review; rather I focus on a few examples to highlight what we know about how epidemics fulminate in crustacean fisheries and what effects they can have on fisheries. Disease issues in cultured species, such as shrimp and crayfish, have been reviewed by Edgerton et al. (2002), Lightner (2005), Flegel (2006) and Walker and Mohan (2009). They will not be covered here.

2. Emergent diseases in lobsters off southern New England

Several disease issues have recently emerged in the fishery for the American lobster, *Homarus americanus* in Long Island Sound and other sounds off southern New England. In 1999, the pathogenic amoeba *Neoparamoeba pemaquidensis* emerged in concert with environmental stressors to decimate the lobster population in western Long Island Sound (Mullen et al., 2004, 2005; Pearce and Balcom, 2005). Mortalities were observed in many crustaceans, including the blue crab (*Callinectes sapidus*), spider crabs (*Libinia* spp.), and the rock crab (*Cancer irroratus*) as well as the horseshoe crab (*Limulus polyphemus*). High temperature stress, increased use of pesticides in response to the introduction of West Nile Virus, and benthic hypoxia appeared to act in synergy with the ameba to cause a catastrophic mortality (Pearce and Balcom, 2005). The mortality subsided in 2000, but the lobster population in Long Island Sound has not recovered (Fig. 1) (Long Island Sound Study, 2011a,b).

Three other disease issues have also emerged in lobsters from the region. In 2002, lobsters from central Long Island Sound were diagnosed with calcinosis, a physiological disorder due to temperature stress (Dove, 2005; Dove et al., 2004, 2005). It was thought to be responsible for smaller mortality events in Long Island Sound. More recently, lobsters in Long Island Sound have been shown to have varying degrees of idiopathic blindness, with prevalence hovering around 50%, and many lobsters having a complete loss of vision (Maniscalco and Shields, 2006; Magel et al., 2009; Shields et al., in press). The causes of the idiopathic blindness were thought to be associated with environmental issues. A more pressing disease issue has emerged in the form of epizootic shell disease. Prior to the mass mortality event in western Long Island Sound and coincidentally after a major oil spill, lobsters from eastern Long Island Sound and Block Island Sound experienced an unusual outbreak of shell disease (Castro and Angell, 2000). The syndrome, now termed epizootic shell disease, continues to be a problem in the region (see below). In addition, in 2000, lobsters from off Maine began dying from "limp lobster" syndrome, a condition caused by infection of *Vibrio fluvialis* (Tall et al., 2003). What made these emerging diseases problematical was the potential for multiple stressors to coincide to cause declines in lobster health and viability on a scale not seen before. These emergent diseases appear related to anthropogenically-induced environmental changes, such as increased bottom temperatures during summers, the general effects of eutrophication (Pearce and Balcom, 2005), and intoxication from contaminants (Zulkosky et al., 2005). Many of these stressors can lead to an immunologically compromised animal (Paterson and Stewart, 1974; DeGuise et al., 2004), that is more susceptible to secondary infections. That is, the emergent disease issues in lobsters in Long Island Sound are indicators of environmental change and anthropogenic degradation of the lobsters' habitat.

Of the disease syndromes mentioned above, epizootic shell disease has received recent attention because of its potential long-term effect on the fishery. Unlike classical shell disease, epizootic disease has not been shown to be horizontally transmitted to healthy lobsters in laboratory experiments (Chistoserdov et al., 2005a,b). It is associated with changes to the bacterial flora, notably by the presence of *Aquimarina homari*, a newly described chitinoclastic bacterium in the Flavobacteriaceae (Chistoserdov et al., in press). Heavily affected animals are not marketable due to gross external pathology (Fig. 2), which in severe cases presents as the nearly complete erosion of the dorsal carapace and claws. The etiology of the syndrome remains to be determined, but it appears to be