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An online operational alert system for the early detection of shrimp epidemics at the regional level based on real-time production

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ABSTRACT

Diseases are among the greatest threats affecting the sustainability of shrimp aquaculture. In Ecuador, diseases of cultured shrimp have been quickly transmitted from one region to another. Therefore, an early detection system of impending epidemics could serve as an important management tool for the aquaculture sector. We developed a system for the early detection of shrimp epidemics for the largest shrimp zone of Ecuador based on production surveillance. The system, called Epidemiological Alert System and Aquaculture Management (SAEMA), uses a geographical information system (GIS) with an imaginary grid cartography (12,860 ha per grid) dividing the study area. A production and management index is calculated with the harvest data of each pond. A standardized deviation around the historical averages and an alert level is calculated per grid and month. Normal conditions of production and therefore the absence of disease are depicted in green and yellow. While, orange and red colours express a disease warning manifested through suboptimal production levels. As a result, a map of the study area with grid divisions is displayed, with a specific alert colour for each grid where information is available. SAEMA was developed as a Web application (http://www.saema.espol.edu.ec) that enables producers to record data via a worksheet format using any web browser. Instantaneously, the applications perform a calculation of the alert index and provide feedback to the alert levels displayed in an interactive map. A feedback process was initiated in May 2006 with 19 participating shrimp farms. The objective of this research is to develop a platform for an early detection of shrimp epidemics on a regional scale. The detection of an epidemic, expressed as suboptimal production in a specific region, can provide producers from other zones and government authorities to engage in time preventive and control measures in order to reduce the spread of diseases.

1. Introduction

Spatial distribution of diseases can be studied using geographical information systems (GIS) (Carpenter, 2001), which are computerized systems with geographically referenced information. GIS advantages include the incorporation of layers of geographically referenced information to maps, cluster analysis, modelling disease spread and planning control strategies, among others. While GIS and information systems are widely used in public health and epidemiology (Glass et al., 1995; Clarke et al., 1996, among several other studies), applications have been relatively less common in veterinary epidemiology (Sanson et al., 1991; Yilma and Malone, 1998; Tum et al., 2004). Moreover, very few studies have been directed towards aquatic animal health. Most studies in aquaculture using GIS have mainly focused on site selection in aquatic farming operations (Aguilar-Manjarrez and Ross, 1995; Nath et al., 2000) and studies of relationship between mangroves and farms (Shahid and Pramanik, 1986). Smith (1999) applied GIS to study patterns of production costs and disease problems in Thai shrimp farms. Recently, a shrimp disease monitoring system using GIS in the Philippines has been reported (Lavilla-Pitogo et al., 2006). However, there are no additional reports of systematic surveillance systems in the shrimp industry using GIS. There are even fewer veterinary disease surveillance systems combining Web-based map services and GIS (Gai, 2003; Staubach et al., 2003; Cameron, 2004; Conte et al., 2005).

Over the past 15 years, the *Penaeus* (*Litopenaeus*) *vannamei* shrimp culture industry in Ecuador has been challenged by a number of serious epidemics quickly transmitted from one region to another (Alday de Graindorge and Griffith, 2001). The most recent disease

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occurred in 1999 when white spot disease (WSD) was detected in northern Ecuador (Esmeraldas) and subsequently spread to the entire shrimp farming industry (Calderón et al., 1999). The economic impact was huge and production dropped from 160,000 tonnes in 1999 to 40,000 tonnes in 2000 (Hill, 2002).

Infectious diseases propagate in a population through spatial–temporal contagious patterns exhibiting clusters. Based on the contagious nature of infectious diseases, we hypothesize that detection of production drops in farms sharing a similar geographic zone could be a cost-effective control system for detecting the onset of an epidemic on a regional level. The detection of an epidemic, expressed as suboptimal production, in a specific region could provide producers from other zones as well as government authorities to engage in timely preventive and control measures.

We developed an online, automated and interactive alert system, called Epidemiological Alert System and Aquaculture Management (SAEMA) for the detection of an epidemic on a regional level (for the largest shrimp producing zone of Ecuador), based on real-time information of production drops, using GIS and novel technology for information systems. The aim of this paper is to describe the structure and contents of SAEMA and to present preliminary results. This is the first report for an automated disease outbreak detection system based on production data for shrimp epidemics at a regional level.

2. Materials and methods

2.1. Study area

The Gulf of Guayaquil (Ecuador), located on the Pacific coast, between latitudes 2°13′S and 4°07′S (Fig. 1), is the largest estuary on the western coast of South America (Cucalón, 1996). SAEMA was developed for Ecuadorian shrimp farms in these zones. The total area of shrimp farms in the region is about 140,000 ha, representing 83% of the Ecuadorian production area.

The climate is tropical and subtropical with two climatic seasons. The wet/warm and dry/cold seasons occur from January to May and from June to December, respectively (Cucalón, 1996). The climatic pattern governs shrimp production, with the highest levels reported during the wet/warm season (Regueira, 2001). Shrimp production also shows variability in space with some zones presenting higher levels than others (Regueira, 2001).

The study area was divided into imaginary rectangular grids, covering approximately 12,860 ha, overlapping with the cartographic grid of the Ecuadorian National Chart (scale 1:25,000; IGM, 1999).

2.2. General methodology

There were three chronological steps involved in the SAEMA development (Fig. 2). In the first step, the tools to identify the alert levels were created. In step 2, the SAEMA platform was implemented building a desktop based GIS that was converted into an online GIS. The Web application enables producers to record data via a defined worksheet format to the SAEMA website using a web browser. The SAEMA website automatically calculates the alert index and provides feedback for the alert levels. Finally, in step 3, the SAEMA feedback at real time was started on May 2006 with data from shrimp farms of the study area.

2.3. Step 1: development of the alert index and alert levels

2.3.1. Alert index

Production and management data were collected from ponds of fifteen large shrimp (*P. vannamei*) farms from the study area for the period 1996–2002. The objective was to build a production variable indicative of farm/pond performance that could be used as an alert variable for the detection of suboptimal production. In order to standardize the information of production among ponds with different management, an index composed of production and management variables was elaborated in the framework of this study (Sonnenholzner et al., 2004). The index, called Production and Management Index (IPM) (Eq. (1)) contains two terms: (1) a standardization of the production, dividing the yield by the stocking density and (2) the shrimp growth rate during the production cycle. The final units were g^2 shrimp^{-1} day^{-1}.

$$\mathrm{IPM} = \left[\frac{\text{Production}}{\text{Pond area}} \times \left(\frac{\text{Number of stocked shrimp}}{\text{Pond area}}\right)^{-1}\right] \times \left[\frac{\text{shrimp weight at harvest}}{\text{duration of the production cycle}}\right]. \quad (1)$$

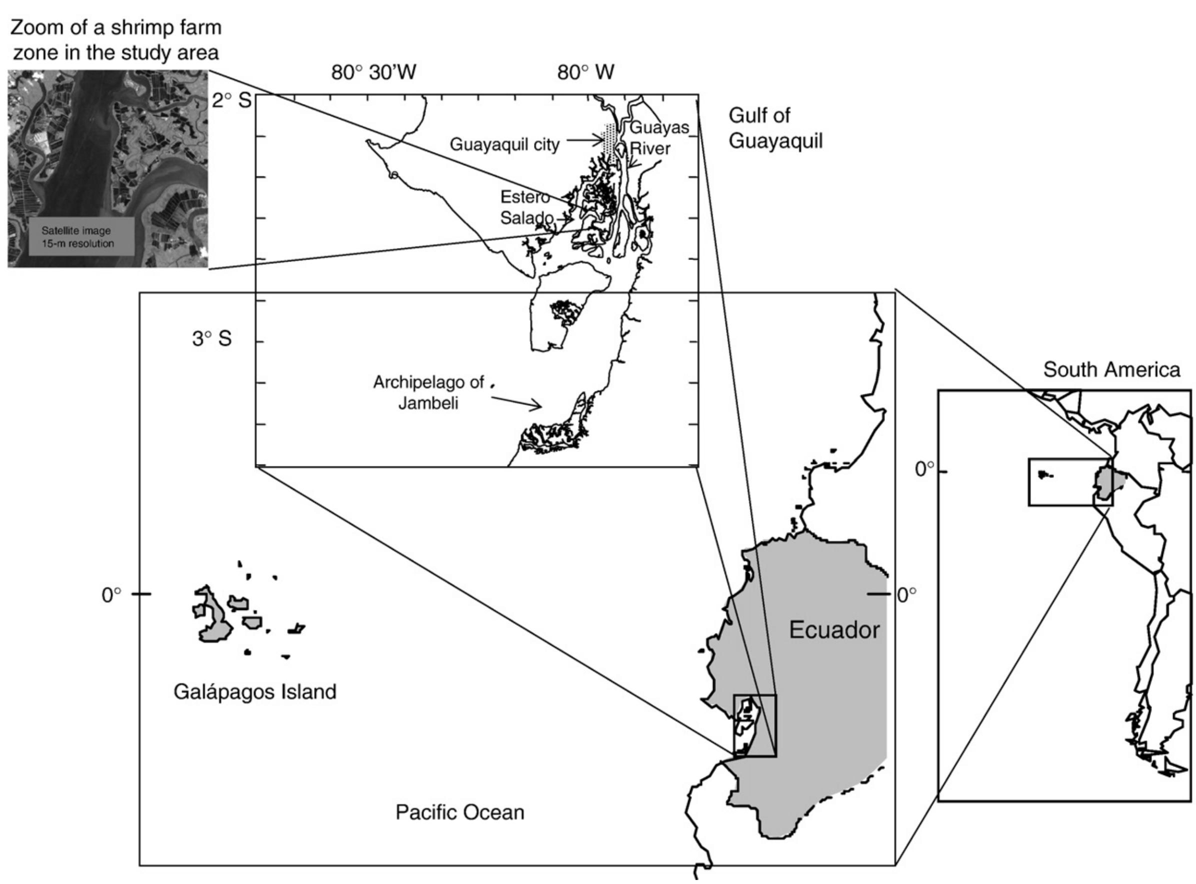

Fig. 1. Study area: shrimp farms located in the Gulf of Guayaquil (Ecuador).